PALÆONTOGRAPHICAL SOCIETY.

VOL. XXXV.

CRETACEOUS ECHINODERMATA.

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AND

I. A CATALOGUE OF THE WORKS ALREADY PUBLISHED;

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Showing the ORDER *of publication; the* YEARS *during which the Society has been in operation; and the* CONTENTS *of each yearly Volume.*

Vol. I. Issued for the Year	1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood, 21 plates.
„ II. „	1848	The Reptilia of the London Clay, Vol. I, Part I, Chelonia, &c., by Profs. Owen and Bell, 38 plates. The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards, 9 plates.
„ III.* „	1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones, 7 plates. The Permian Fossils, by Prof. Wm. King, 29 plates. The Reptilia of the London Clay, Vol. I, Part II, Crocodilia and Ophidia, &c., by Prof. Owen, 18 plates. The Fossil Corals, Part I, Crag, London Clay, Cretaceous, by Messrs. Milne Edwards and Jules Haime, 11 plates.
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„ V. „	1851	The Reptilia of the Cretaceous Formations, by Prof. Owen, 39 plates. The Fossil Corals, Part II, Oolitic, by Messrs. Milne Edwards and Jules Haime, 19 plates. The Fossil Lepadidæ, by Mr. Charles Darwin, 5 plates.
„ VI. „	1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne Edwards and Jules Haime, 16 plates. The Fossil Brachiopoda, Part I, Tertiary, by Mr. Davidson, 2 plates. The Fossil Brachiopoda, Part II, No. 1, Cretaceous, by Mr. Davidson, 5 plates. The Fossil Brachiopoda, Part III, No. 2, Oolitic and Liassic, by Mr. Davidson, 5 plates. The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards, 6 plates. The Radiaria of the Crag, London Clay, &c., by Prof. E. Forbes, 4 plates.
„ VII. „	1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne Edwards and Jules Haime, 10 plates. The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson, 9 plates. The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe, 10 plates. The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett, 8 plates. The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood, 8 plates. The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen, 9 plates.

* The volume for the year 1849 consists of two separate portions, each of which is stitched in a paper cover, on which are printed the dates 1848, 1849, and 1850.

CATALOGUE OF WORKS—Continued.

Vol. VIII.	Issued for the Year	*1854	The Fossil Brachiopoda, Part II, No. 2, Cretaceous, with Appendix and Index to Vol. I, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen, 20 plates. The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett, 7 plates. The Fossil Corals, Part V, Silurian, by Messrs. Milne Edwards and Jules Haime, 16 plates. The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin, 2 plates. The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe, 6 plates. The Eocene Mollusca, Part III, No. 1, Prosobranchiata, by Mr. F. E. Edwards, 8 plates.
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„ XII.	„	1858	The Fossil Echinodermata, Oolitic, Vol. I, Part IV, by Dr. Wright, 7 plates. The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards, 6 plates. The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen, 7 plates. The Reptilia of the Purbeck Limestones, by Prof. Owen, 1 plate. The Fossil Brachiopoda, Part V, No. 3, Carboniferous, by Mr. Davidson, 10 plates.
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„ XIV.	„	1860	The Fossil Brachiopoda, Part V, No. 5, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Oolitic Formations, No. 2, Lower Lias, by Prof. Owen, 11 plates. The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen, 1 plate. The Fossil Estheriæ, by Prof. Rupert Jones, 5 plates. The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell, 11 plates.
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Vol. XVI.	Issued for the Year 1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part I (Devonian and Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VI, No. 1, Devonian, by Mr. Davidson, 9 plates. The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood, 7 plates. The Reptilia of the Cretaceous and Wealden Formations (Supplements), by Prof. Owen, 10 plates.
„ XVII.	„ 1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter, 8 plates. The Fossil Brachiopoda, Part VI, No. 2, Devonian, by Mr. Davidson, 11 plates. The Belemnitidæ, Part I, Introduction, by Prof. Phillips. The Reptilia of the Liassic Formations, Part I, by Prof. Owen, 16 plates.
„ XVIII.	„ 1864	The Fossil Echinodermata, Oolitic, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX.*	„ 1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
„ XX.*	„ 1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
„ XXI.*	„ 1867	Flora of the Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.
„ XXII.*	„ 1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.
„ XXIII.*	„ 1869	Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright, 10 plates. The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips, 9 plates. The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester, 9 plates. The Reptilia of the Liassic Formations, Part II, by Prof. Owen, 4 plates. The Crag Cetacea, No. 1, by Prof. Owen, 5 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

CATALOGUE OF WORKS—Continued.

Vol. XXIV.*	Issued for the Year 1870	The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright, 10 plates. The Fossil Brachiopoda, Part VII, No. 4, Silurian, by Mr. Davidson, 13 plates. The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood, 5 plates. The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen, 4 plates.
„ XXV*	„ 1871	The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney, 6 plates. The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward, 5 plates. Supplement to the Crag Mollusca, Part I (Univalves), by Mr. S. V. Wood, with an Introduction on the Crag District, by Messrs. S. V. Wood, jun., and F. W. Harmer, 7 plates and map. Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen, 3 plates The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs W. Boyd Dawkins and W. A. Sanford, 2 plates. The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins, 5 plates.
„ XXVI.*	„ 1872	Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan, with an Index to the Tertiary and Secondary Species, 7 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright, 5 plates. The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward, 10 plates. The Fossil Trigoniæ, No. I, by Dr. Lycett, 9 plates.
„ XXVII*	„ 1873	The Fossil Echinodermata, Cretaceous, Vol I, Part VI, by Dr. Wright, 8 plates. Supplement to the Fossil Brachiopoda, Part I (Tertiary and Cretaceous), by Mr. Davidson, 8 plates. Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood, 5 plates. Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen, 2 plates. Supplement to the Reptilia of the Wealden (Hylæochampsa) No. VI, by Prof. Owen. The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen, 2 plates.
„ XXVIII*	„ 1874	The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, 16 plates. The Carboniferous Entomostraca, Part I (Cypridinadæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, 5 plates. The Fossil Trigoniæ, No. II, by Dr. Lycett, 10 plates.
„ XXIX*	„ 1875	The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright, 10 plates. The Fossil Trigoniæ, No. III, by Dr. Lycett, 8 plates. The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen, 20 plates.
„ XXX.*	„ 1876	The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady, 12 plates. Supplement to the Fossil Brachiopoda, Part II, No. 1 (Jurassic and Triassic), by Mr. Davidson, 8 plates. Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen, 6 plates.
„ XXXI.*	„ 1877	Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates. The Fossil Trigoniæ, No. IV, by Dr. Lycett, 13 plates. The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood, 1 plate. The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair, 7 plates. The Fossil Reptilia of the Mesozoic Formations, Part III, by Prof. Owen, 2 plates. The Fossil Elephants (E. antiquus), Part I, by Prof. Leith Adams, 5 plates.

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CATALOGUE OF WORKS—Continued.

Vol. XXXII.*	Issued for the Year 1878	The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright, 8 plates. Index and Title Page to the Fossil Echinodermata, Oolitic, Vol. I (Echinoidea), by Dr. Wright. The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward, 6 plates. Supplement to the Fossil Brachiopoda, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson, 13 plates. The Lias Ammonites, Part I, by Dr. Wright, 8 plates. The Sirenoid and Crossopterygian Ganoids, Part I, by Prof. Miall, 6 plates. Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen, 6 plates. The Pleistocene Mammalia, Part A (Preliminary Treatise), by Prof. Boyd Dawkins.
„ XXXIII*	„ 1879	The Eocene Flora, Part I, by Mr. J. S. Gardner and Baron Ettingshausen, 5 plates. Second Supplement to the Crag Mollusca (Univalves and Bivalves), by Mr. S. V. Wood, 6 plates. The Fossil Trigoniæ, No. V (*Conclusion*), by Dr. Lycett, 1 plate. The Lias Ammonites, Part II, by Dr. Wright, 10 plates. Supplement to the Reptilia of the Wealden (Goniopholis, Brachydectes, Nannosuchus, Theriosuchus, and Nuthetes), No. IX, by Prof. Owen, 4 plates. The Fossil Elephants (E. primigenius), Part II, by Prof. Leith Adams, 10 plates.
„ XXXIV*	„ 1880	The Eocene Flora, Part II, by Mr. J. S. Gardner and Baron Ettingshausen, 6 plates. The Fossil Echinodermata, Oolitic, Vol. II, Part III (Asteroidea and Ophiuroidea), by Dr. Wright, 3 plates. Supplement to the Fossil Brachiopoda, Part III (Permian and Carboniferous), by Mr. Davidson, 8 plates. The Lias Ammonites, Part III, by Dr. Wright, 22 plates. The Reptilia of the London Clay, Vol. II, Part I (Chelone) by Prof. Owen, 2 plates.
„ XXXV*	„ 1881	The Fossil Echinodermata, Cretaceous, Vol. I, Part IX, by Dr. Wright, 6 plates. Supplement to the Fossil Brachiopoda, Part IV (Devonian and Silurian, from Budleigh-Salterton Pebble Bed), by Mr. Davidson, 5 plates. The Fossil Trigoniæ (Supplement), by Dr. Lycett. The Lias Ammonites, Part IV, by Dr. Wright, 10 plates. The Reptilia of the Liassic Formations, Part III (*Conclusion*), by Prof. Owen, 13 plates. The Fossil Elephants (E. primigenius and E. meridionalis), Part III (*Conclusion*), by Prof. Leith Adams, 13 plates.

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§ II. LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

1. MONOGRAPHS which have been COMPLETED, and which may be bound as separate Volumes:—

The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady. (*Complete in the Volume for the year* 1876.)

The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime. (*Complete in the Volumes for the years* 1849, 1851, 1852, 1853, *and* 1854. *The Title-page and Index, with corrected explanations of Plates XVII and XVIII, will be found in the Volume for the year* 1854.)

The Polyzoa of the Crag, by Mr. G. Busk. (*Complete with Title-page and Index in the Volume for the year* 1857.)

The Tertiary Echinodermata, by Professor Forbes. (*Complete with Title-page in the Volume for the year* 1852.)

The Fossil Cirripedes, by Mr. C. Darwin. (*Complete in the Volumes for the years* 1851, 1854, *and* 1858. *The Title-page will be found in the Volume for the year* 1854, *and the Index in the Volume for the year* 1858.

The Post-Tertiary Entomostraca, by Mr. G. S. Brady, the Rev. H. W. Crosskey, and Mr. D. Robertson. (*Complete, with Title-page and Index, in the Volume for the year* 1874.)

The Tertiary Entomostraca, by Prof. T. Rupert Jones. (*Complete, with Title-page and Index, in the Volume for the year* 1855.)

The Cretaceous Entomostraca, by Prof. T. Rupert Jones. (*Complete, with Title-page and Index, in the Volume for the year* 1849.)

The Fossil Estheriæ, by Prof. T. Rupert Jones. (*Complete, with Title-page and Index, in the Volume for the year* 1860.)

The Fossil Merostomata, by Dr. H. Woodward. (*Complete in the Volumes for the years* 1865, 1868, 1871, 1872, *and* 1878. *The Title-page and Index, with directions for the binding, will be found in the Volume for the year* 1878.)

The Tertiary, Cretaceous, Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson. (*Complete in the Volumes for the years* 1850, 1852, 1853, *and* 1854. *The Index will be found in the Volume for the year* 1854, *and corrected Title-page in that for* 1870.)

The Permian and Carboniferous Brachiopoda, by Mr. T. Davidson. (*Complete in the Volumes for the years* 1856, 1857, 1858, 1859, *and* 1860. *The Index will be found in the Volume for the year* 1860, *and corrected Title-page in that for* 1870.)

The Devonian and Silurian Brachiopoda, by Mr. T. Davidson. (*Complete in the Volumes for the years* 1862, 1863, 1865, 1866, 1868, *and* 1870. *The Title-page and Index will be found in the Volume for the year* 1870.)

The Eocene Bivalves, Vol. I, by Mr. S. V. Wood. (*Complete, with Title-page and Index, in the Volumes for the years* 1859, 1862, *and* 1870. *The directions for the binding will be found in the Volume for the year* 1870.)

Supplement to the Eocene Bivalves, by Mr. S. V. Wood. (*Complete, with Title-page and Index, in the Volume for the year* 1877.)

The Eocene Cephalopoda and Univalves, Vol. I, by Mr. F. E. Edwards and Mr. S. V. Wood. (*Complete in the Volumes for the years* 1848, 1852, 1854, 1855, 1858, *and* 1877. *The Title-page, Index, and directions for the binding, will be found in the Volume for the year* 1877.)

The Mollusca of the Crag, Vol. I, Univalves, by Mr. S. V. Wood. (*The Text, Plates, and Index, will be found in the Volume for the year* 1847, *and the Title-page will be found in the Volume for the year* 1855.)

The Mollusca of the Crag, Vol. II, Bivalves, by Mr. S. V. Wood. (*Complete in the Volumes for the years* 1850, 1853, 1855, 1858, *and* 1873. *The Title-page will be found in the Volume for the year* 1873, *and Index will be found in the Volume for the year* 1855, *and a Note in the Volume for the year* 1858).

The Mollusca of the Crag, Vol. III, Supplement, by Mr. S. V. Wood. (*Complete in the Volumes for the years* 1871 *and* 1873. *The Title-page and Index will be found in the Volume for the year* 1873.)

Second Supplement to the Crag Mollusca, by Mr. S. V. Wood. (*Complete, with Title-page and Index, in the Volume for the year* 1879.)

The Great Oolite Mollusca, by Professor Morris and Dr. Lycett. (*Complete in the Volumes for the years* 1850, 1853, *and* 1854. *The Title-page and Index will be found in the Volume for the year* 1854.)

The Fossil Trigoniæ, by Dr. Lycett. (*Complete in the Volumes for the years* 1872, 1874, 1875, 1877, *and* 1879. *The directions for the binding will be found in the Volume for the year* 1879.)

The Oolitic Echinodermata, Vol. I, Echinoidea, by Dr. Wright. (*Complete in the Volumes for the years* 1855, 1856, 1857, 1858, *and* 1878. *Title-page, Index, and directions for the binding, will be found in the Volume for the year* 1878.)

The Oolitic Echinodermata, Vol. II, Asteroidea, by Dr. Wright. (*Complete in the Volumes for the years* 1861, 1864, *and* 1880. *Title-page, Index, and directions for the binding, will be found in the Volume for the year* 1880).

The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe. (*Complete in the Volumes for* 1853, 1854, *and* 1855, *but wants Title-page and Index.*)

The Fossils of the Permian Formation, by Professor King. *Complete, with Title-page and Index, in the Volume for the year* 1849. *Corrected explanations of Plates XXVIII and XXVIII* will be found in the Volume for the year* 1854.)

The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), Vol. I, by Professors Owen and Bell. (*Complete in the Volumes for the years* 1848, 1849, 1856, *and* 1864. *Directions for the binding, Title-page, and Index, will be found in the Volume for the year* 1864.)

The Reptilia of the Cretaceous Formations, by Prof. Owen. (*Complete in the Volumes for the years* 1851, 1857, 1858, 1862, *and* 1864. *Directions for the binding, Title-page, and Index, will be found in the Volume for the year* 1864.)

The Reptilia of the Wealden and Purbeck Formations, by Professor Owen. (*Complete in the Volumes for the years* 1853, 1854, 1855, 1856, 1857, 1858, 1862, *and* 1864. *Directions for the binding, Title-pages, and Index, will be found in the Volume for the year* 1864.)

The Reptilia of the Liassic Formations, by Professor Owen. (*Complete in the Volumes for the years*, 1859, 1860, 1863, 1869, *and* 1881. *Directions for the binding, Title-pages, and Index, will be found in the Volume for the year* 1881.)

The Fossil Mammalia of the Mesozoic Formations, by Professor Owen. (*Complete, with Title-page and Table of Contents, in the Volume for the year* 1870.)

The Fossil Elephants, by Professor Leith Adams. (*Complete in the Volumes for the years* 1877, 1879, *and* 1881. *Title-page and Index will be found in the Volume for the year* 1881. *Directions for the binding will be found in the Volume for the year* 1881.)

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2. MONOGRAPHS in course of Publication :*—

The Eocene Flora, by Mr. J. S. Gardner and Baron Ettingshausen.

The Flora of the Carboniferous Formation, by Mr. E. W. Binney.

The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.

Supplement to the Fossil Corals, by Dr. Duncan.

The Echinodermata of the Cretaceous Formation, by Dr. Wright.

The Carboniferous Entomostraca, by Messrs. T. Rupert Jones, J. W. Kirkby, and G. S. Brady.

The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.†

The Malacostracous Crustacea, by Professor Bell.

Supplement to the Fossil Brachiopoda, by Mr. T. Davidson.

Supplement to the Fossil Trigoniæ, by Dr. Lycett.

The Ammonites of the Lias, by Dr. Wright.

The Belemnites, by Professor Phillips.‡

The Sirenoid and Crossopterygian Ganoids, by Professor Miall.

The Fishes of the Carboniferous Formation, by Prof. Traquair.

The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, and Professor Traquair.

The Reptilia of the Wealden Formation (Supplements), by Professor Owen.

The Reptilia of the Kimmeridge Clay, by Professor Owen.

The Reptilia of the Mesozoic Formations, by Professor Owen.

The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.

The Cetacea of the Crag, by Professor Owen.

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* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

† Unfinished through the death of the Author, but will be continued by Dr. H. Woodward.

‡ Unfinished through the death of the Author, but will be continued by Mr. R. Etheridge.

3. MONOGRAPHS which are in course of PREPARATION :— *

The Fossil Cycadeæ, by Mr. W. Carruthers.

The Fossil Sponges, by Mr. W. J. Sollas.

The Rhizopoda of the Chalk, Chalk Marl, Gault, and Upper Greensand, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.

The Foraminifera of the Lias, by Mr. H. B. Brady.

The Graptolites, by Professor Sir Wyville Thomson.

The Polyzoa of the Chalk Formation, by Mr. G. Busk.

The Palæozoic Polyzoa, by Dr. Duncan.

The Crinoidea, by Professor Sir Wyville Thomson.

Supplement to the Tertiary and Cretaceous Entomostraca, by Prof. T. Rupert Jones.

The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. R. Jones and G. S. Brady.

The Post-Tertiary Mollusca, by Dr. J. Gwyn Jeffreys.

The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.

The Purbeck Mollusca, by Mr. R. Etheridge.

The Inferior Oolite Mollusca, by Mr. R. Etheridge.

The Rhætic Mollusca, by Mr. R. Etheridge.

The Carboniferous Bivalve Mollusca, by Mr. R. Etheridge, junr.

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* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

§ III. Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

Volume	I	for	1847	was	issued	to	the Members,	March, 1848.
,,	II	,,	1848	,,	,,	,,		July, 1849.
,,	III	,,	1849	,,	,,	,,		August, 1850.
,,	IV	,,	1850	,,	,,	,,		June, 1851.
,,	V	,,	1851	,,	,,	,,		June, 1851.
,,	VI	,,	1852	,,	,,	,,		August, 1852.
,,	VII	,,	1853	,,	,,	,,		December, 1853.
,,	VIII	,,	1854	,,	,,	,,		May, 1855.
,,	IX	,,	1855	,,	,,	,,		February, 1857.
,,	X	,,	1856	,,	,,	,,		April, 1858.
,,	XI	,,	1857	,,	,,	,,		November, 1859.
,,	XII	,,	1858	,,	,,	,,		March, 1861.
,,	XIII	,,	1859	,,	,,	,,		December, 1861.
,,	XIV	,,	1860	,,	,,	,,		May, 1863.
,,	XV	,,	1861	,,	,,	,,		May, 1863.
,,	XVI	,,	1862	,,	,,	,,		August, 1864.
,,	XVII	,,	1863	,,	,,	,,		June, 1865.
,,	XVIII	,,	1864	,,	,,	,,		April, 1866.
,,	XIX	,,	1865	,,	,,	,,		December, 1866.
,,	XX	,,	1866	,,	,,	,,		June, 1867.
,,	XXI	,,	1867	,,	,,	,,		June, 1868.
,,	XXII	,,	1868	,,	,,	,,		February, 1869.
,,	XXIII	,,	1869	,,	,,	,,		January, 1870.
,,	XXIV	,,	1870	,,	,,	,,		January, 1871.
,,	XXV	,,	1871	,,	,,	,,		June, 1872.
,,	XXVI	,,	1872	,,	,,	,,		October, 1872.
,,	XXVII	,,	1873	,,	,,	,,		February, 1874.
,,	XXVIII	,,	1874	,,	,,	,,		July, 1874.
,,	XXIX	,,	1875	,,	,,	,,		December, 1875.
,,	XXX	,,	1876	,,	,,	,,		December, 1876.
,,	XXXI	,,	1877	,,	,,	,,		February, 1877.
,,	XXXII	,,	1878	,,	,,	,,		March, 1878.
,,	XXXIII	,,	1879	,,	,,	,,		May, 1879.
,,	XXXIV	,,	1880	,,	,,	,,		May, 1880.
,,	XXXV	,,	1881	,,	,,	,,		May, 1881.

§ IV. SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* MAY, 1881): *showing in the* FIRST *column whether each Monograph hitherto published be* complete, *or in the* course of completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* FOURTH *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
The Flora of the Eocene Formations, by Mr. J. S. Gardner and Baron Ettingshausen, *in course of completion*	1879, 1880	1879, 1880	58	11	115	22
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, *in course of completion*	1867, 1870, 1871, 1875	1868, 1871, 1872, 1875	147	24	141	16
The Crag Foraminifera, by Messrs. T Rupert Jones, W. K. Parker, and H. B. Brady, *in course of completion*	1865	1866	78	4	211	43
The Carboniferous and Permian Foraminifera (genus Fusilina excepted), by Mr. H. B. Brady, COMPLETE	1876	1876	166	12	266	62
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, COMPLETE (*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Prof. Duncan, *in course of completion*	1865, 1866, 1867, 1868, 1869, 1872	1866, 1867, 1868, 1869, 1870, 1872	232	49	797	149
The Polyzoa of the Crag, by Mr. G. Busk, COMPLETE	1857	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, COMPLETE	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, COMPLETE (*l*)	1855, 1856, 1857, 1858, 1878	1857, 1858, 1859, 1861, 1878	491	43	724	120*h*
„ „ Vol. II, COMPLETE	1861, 1864, 1880	1863, 1866, 1880	207	22	232	35
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, *in course of completion*	1862, 1867, 1869, 1870, 1872, 1873, 1875, 1878, 1881	1864, 1868, 1870, 1871, 1872, 1874, 1875, 1878, 1881	324	82	1058	107
The Fossil Cirripedes, by Mr. C. Darwin, COMPLETE	1851, 1854, 1858*a*	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Dr. H. Woodward, COMPLETE	1865, 1868, 1871, 1872, 1878	1866, 1869, 1872, 1872, 1878	265	36	365	51
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, COMPLETE	1874	1874	237	16	515	134
The Tertiary Entomostraca, by Prof. Rupert Jones, COMPLETE	1855	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, COMPLETE	1849	1850	41	7	176	27
The Carboniferous Entomostraca, by Prof. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, *in course of completion*	1874	1874	56	5	285	50
The Fossil Estheriæ, by Prof. Rupert Jones, COMPLETE	1860	1863	139	5	158	19*i*
		CARRIED FORWARD...	3242	427	7181	1430

Summary of the Monographs issued to the Members (*up to* MAY, 1881)—*continued.*

I. Subject of Monograph.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
		Brought forward...	3242	427	7181	1430
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter (incomplete through the Author's death)	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, *in course of completion*	1856, 1860	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, COMPLETE	1850, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
„ „ Vol. II. The Permian and Carboniferous Brachiopoda, COMPLETE	1856*d*, 1857, 1858, 1859, 1860	1858, 1859, 1861, 1861, 1863	331	59	1909	157
„ „ Vol. III. The Devonian and Silurian Brachiopoda, COMPLETE	1862, 1863, 1865, 1866, 1868, 1870	1864, 1865, 1866, 1867, 1869, 1871	528	70	2766	321
Supplement to the Fossil Brachiopoda, by Mr. Davidson, *in course of completion*	1873, 1876, 1878, 1880, 1881	1874, 1876, 1878, 1880, 1881	368	42	1664	215
The Fossil Trigoniæ, by Dr. Lycett, COMPLETE	1872, 1874, 1875, 1877, 1879	1872, 1874, 1875, 1877, 1879	246	41	446	115
Supplement to the Fossil Trigoniæ, by Dr. Lycett, *in course of completion*	1881	1881	3	0	4	0*h*
The Mollusca of the Crag, by Mr. S. V. Wood:—						
Vol. I. (Univalves), COMPLETE	1847, 1855*b*	1848, 1857	216	21	581	244
Vol. II. (Bivalves), COMPLETE	1850, 1853, 1855, 1858*c*	1851, 1853, 1857, 1861	344	31	691	253
Supplements to the Crag Mollusca, No. I and II, by Mr. S. V. Wood, COMPLETE	1871, 1873, 1879	1872, 1874, 1879	322	18	517	232
The Eocene Mollusca, Cephalopoda and Univalves, by Mr.F. E. Edwards, continued by Mr. S. V. Wood. Vol. I, COMPLETE	1848, 1852, 1854, 1855, 1858, 1877	1849, 1852, 1855, 1857, 1861, 1877	361	34	625	275
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood. Vol. I, COMPLETE	1859, 1862, 1870	1861, 1864, 1871	182	25	531	194
Supplement to the Eocene Mollusca, by Mr. S. V. Wood (Bivalves). Vol. I, COMPLETE	1877	1877	24	2	66	30
The Great Oolite Mollusca, by Prof. Morris and Dr. Lycett, COMPLETE	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
„ „ „ Supplement by Dr. Lycett, COMPLETE	1861	1863	129	15	337	194
The Liassic Ammonites, by Dr. Wright, *in course of completion*	1878, 1879, 1880, 1881	1878, 1879, 1880, 1881	328	50	470	28
The Belemnites, by Prof. Phillips, *in course of completion*	1863, 1864, 1866, 1868, 1869	1865, 1866, 1867, 1869, 1870	128	36	622	69
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, COMPLETE	1853, 1854, 1855	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, COMPLETE	1849, 1854*e*	1850, 1855	287	29	511	138
		Carried forward...	8101	1052	22,859	4717

Summary of the Monographs issued to the Members (*up to* MAY, 1881)—*continued.*

I. Subject of Monograph.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
		Brought forward...	8101	1052	22,859	4717
The Sirenoid Ganoids, by Prof. Miall, *in course of completion*	1878	1878	32	6	61	6
The Fishes of the Carboniferous Formation, by Dr. Traquair, *in course of completion*	1877	1877	60	7	58	5
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, *in course of completion*	1867, 1869	1868, 1870	62	14	195	21
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, Vol. I, complete ‡	1848, 1849, 1856*f*	1849, 1850, 1859	150	58	304	39
„ „ Vol. II, Part I, by Prof. Owen, *in course of completion*	1880	1880	4	2	4	1
The Reptilia of the Cretaceous Formations, by Prof. Owen, complete ‡	1851, 1857, 1858, 1862	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, complete ‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Wealden Formations (Supplements) *in course of completion*	1871, 1873, 1876, 1878, 1879	1872, 1874, 1876, 1878, 1879	81	21	175	15
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, *in course of completion*	1859, 1860, 1868	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, complete	1859,‖ 1860,‖ 1863, 1869, 1881*n*	1861, 1863, 1865, 1870, 1881	174	50	276	20
The Reptilia of the Mesozoic Formations, by Prof. Owen, *in course of completion*	1873, 1875, 1877	1874, 1875, 1877	97	24	165	17
The Crag Cetacea, by Prof. Owen, *in course of completion*	1869	1870	40	5	43	7
The Fossil Elephants, by Prof. Leith Adams, complete	1877, 1879, 1881*n*	1877, 1879, 1881	265	28	216	3
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, *in course of completion*	1864, 1867, 1868, 1871, 1878	1866, 1868, 1869, 1872, 1878	304	32	253	7
The Mammalia of the Mesozoic Formations, by Prof. Owen, complete	1870	1871	115	4	247	30
		Total.....	9840	1430	25,649	4934

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Index will be found in 1878 vol. *m* Useful for establishing the dates of new species. *n* Contains title-pages and directions for binding.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately. ‖ Marked on outside label 'Reptilia of Oolitic Formations.'

§ V. Stratigraphical Table *exhibiting the* British Fossils *already figured and described in the* Annual Volumes (1847—1881) *of the* Palæontographical Society.

	PLANTS.	PROTOZOA.		RADIATA.		ARTICULATA.					
		Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.
Pleistocene	...	...	...	...	.....	.....	1874				
Crag	...	...	1865	1849	1852	1851 1854					
Eocene	1879 1880	...	...	1849 1865	1852	1851 1854	1855	...	.....	.....	1856
Cretaceous.....	...	...	...	1849 1868 1869	1862 1867 1869 1870 1872 1873 1875 1878 1881	1851 1854	1849	...	.....	.....	1860
Wealden	...	...	...	...	.....	.....	...	1860			
Oolitic	...	...	...	1851 1872	1855, 1856, 1857, 1858, 1861, 1878, 1880	1851	...	1860			
Liassic	...	...	...	1851 1866 1867	1855, 1856, 1858, 1861, 1864						
Triassic	...	...	...	...	1880	.....	...	1860			
Permian	1849	1849	1849 1876	1849 1852	1849	.....	1849	1860			
Carboniferous...	1867 1870 1871 1875	...	1876	1852	.....	.....	1874	1860	1872 1878		
Devonian	...	...	...	1853	.....	.....	...	1860	1865 1868 1872 1878	1862	
Silurian.....	...	...	...	1854	.....	.....	...	...	1868 1871 1872 1878	1862, 1863 1864, 1866	
Cambrian	...	...	...	...	.....	.....	...	...	.....	1864	

Note.—The numbers in the above List refer to the Volumes issued for those Dates.

STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1881) *of the* PALÆONTOGRAPHICAL SOCIETY (*continued*).

	MOLLUSCA.				VERTEBRATA.		
	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene	...	1873	.....	...	...	.....	1864, 1867, 1868, 1871, 1877, 1878, 1879, 1881
Crag	1857	1852, 1873, 1879	1847, 1850, 1853, 1855, 1871, 1873, 1879	...	...	.....	1869, 1881
Eocene	...	1852, 1873	1852, 1854, 1855, 1858, 1859, 1862, 1870, 1877	1848	...	1848, 1849, 1856, 1880	
Cretaceous.....	...	1852, 1854, 1873	1872, 1875, 1877, 1879	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	... ..	.....	...	...	1853, 1854, 1855, 1856, 1857, 1862, 1871, 1873, 1875, 1876, 1878, 1879	
Oolitic	...	1850, 1852, 1876, 1878,	1850, 1853, 1854, 1872, 1874, 1875, 1877, 1879	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868, 1873, 1875, 1877 (Great Oolite) 1875	1870
Liassic	...	1850, 1852, 1876, 1878	1874, 1877, 1879	1863, 1864, 1866, 1868, 1878, 1879, 1880, 1881	...	1859, 1860, 1863, 1869, 1873, 1881	
Triassic.....	...	1876, 1878	1879	.....	1878	.....	1870
Permian	1849	1849, 1856, 1880	1849	1849	1849	1849	
Carboniferous ...	...	1856, 1857, 1858, 1859, 1860, 1880	.....	.....	1877		
Devonian	...	1862, 1863, 1881	.....	.....	1867, 1869		
Silurian.....	...	1865, 1866, 1868, 1870, 1881					
Cambrian							

NOTE.—The numbers in the above List refer to the Volumes issued for those Dates.

THE

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MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE; THE SOCIETY OF NATURAL SCIENCES OF NEUCHÂTEL; VICE-PRESIDENT OF THE COTTESWOLD NATURALISTS' FIELD CLUB; CONSULTING SURGEON TO THE CHELTENHAM HOSPITAL; AND MEDICAL OFFICER OF HEALTH TO THE URBAN SANITARY DISTRICTS OF CHELTENHAM, CHARLTON KINGS, AND LECKHAMPTON.

VOLUME FIRST.

PART NINTH.

ON THE ECHINOCORIDÆ.

Pages 301—324; Plates LXX—LXXV.

LONDON:

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1881.

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J. E. ADLARD, BARTHOLOMEW CLOSE.

CARDIASTER PYGMÆUS, *Forbes*. Pl. LXIX, figs. 1 *a*—*e*.

CARDIASTER PYGMÆUS,	*Forbes*.	Ann. Nat. Hist., 2nd ser., vol. vi, p. 444, 1850.
—	— *Forbes*.	Mem. Geol. Surv., decade iv, pl. ix, notes, 1852.
—	— *Morris*.	Catal. of Brit. Foss., 2nd ed., p. 73, 1854.

Diagnosis.—Test very small, ovate, and cordate; anterior channel large; ambulacral areas wide, sparsely covered with microscopic tubercles; posterior border truncated vertically; periprocte in the upper third; upper surface gently rounded, with an elevated carina between the apical disc and the upper margin of the periprocte.

Dimensions.—A middle-sized specimen measured in the antero-posterior diameter half an inch; in the transverse diameter five twelfths of an inch, and in height four twelfths of an inch. It is found, however, that the proportions vary considerably.

Description.—This small *Cardiaster* is common in the Chalk at Dover, where many good specimens were collected several years ago by Major C. F. Cockburn, R.A., who kindly supplied examples for this work. The outline of the test is ovate, gently rounded on the upper surface (Pl. LXIX, figs. 1 *d*, *e*), and provided with a subcarinated ridge, which rises behind the apical disc (fig. 1 *a*), and extends backwards to the upper border of the periprocte (fig. 1 *d*). The anteal sulcus is wide (figs. 1 *a*, *e*) and strongly carinated, and the posterior border is sharply truncated (fig. 1 *c*); the oval periprocte opens in the upper third (fig. 1 *d*); the sides of the test are moderately inflated (figs. 1 *e* and 1 *c*), and the view from the base shows the ovato-cordate ambitus of this beautiful little Urchin (fig. 1 *b*).

The ambulacral areas are acutely lanceolate on the upper surface, the antero-lateral curve a little backwards, and the postero-lateral pass direct to the disc; the poriferous avenues are very narrow, and the pores in single pairs are set closely together.

The surface of the test appears to be perfectly smooth. When examined with a lens, however, it is seen to be covered with minute granules, among which a number of primary tubercles of small size are scattered (fig. 1 *a*, *b*, *c*).

The base is flat at the sides, and has a central elevated ridge, which extends from the peristome to the posterior border (fig. 1 *c*, *b*); the mouth is transversely oblong, and situated near the anterior border (fig. 1 *b*).

Affinities and Differences.—This Urchin when magnified two diameters, as it is in our figures, has a striking resemblance to *Holaster lævis;* but differs in having the anteal sulcus deeper and wider, its sides more angular, and the posterior border broader and more sharply truncated than in that species; the mouth is also nearer the anterior border.

Locality and Stratigraphical Position.—This small Urchin has hitherto been found only in the Upper White Chalk at Dover, Kent, and was first briefly noted by the late Prof. Edw. Forbes, F.R.S., in the 'Ann. and Mag. of Nat. History,' 2nd series, December, 1850.

CARDIASTER ANANCHYTIS,[1] *Leske.* Pl. LXIX, figs. 2 *a*—*i*, 3.

SPATANGUS ANANCHYTIS,	*Leske.*	Addit. ad Kleinii Echin., p. 243, pl. liii, figs. 1, 2, 1778.
ECHINUS ANANCHYTIS,	*Gmelin.*	Sytema Naturæ, p. 3199, No. 97, 1789.
— —		Encyclopéd. Méth., Mollus. et Zooph., Atlas, pl. clvii, figs. 7—10, 1791.
ANANCHYTES CORDATA,	*Lamarck.*	Anim. sans vertèbres, t. iii, p. 26, No. 8, 1816.
SPATANGUS GRANULOSUS,	*Goldfuss.*	Petref. Germaniæ, p. 148, pl. xlv, fig. 3, 1826.
— —	*Desmoulins.*	Études des Echinides, p. 410, 1835.
— CORDIFORMIS,	*Woodward.*	Geol. of Norfolk, p. 50, pl. v, fig. 6, 1833.
HOLASTER GRANULOSUS,	*Agassiz.*	Prodrome, p. 16, 1836.
— —	*Agassiz & Désor.*	Cat. Rais. des Échinides, in Ann. des Sc. Nat., 3rd. ser., vol. viii, p. 27, 1847.
— ÆQUALIS,	*Portlock.*	Geol. Rep. Londonderry, p. 355, pl. xvii, 1843.
— CORDIFORMIS,	*Forbes.*	Ann. Nat. Hist., 2nd ser., vol. vi, p. 443, 1850.
CARDIASTER GRANULOSUS,	*Forbes.*	Mem. of the Geol. Survey, decade iv, pl. ix, 1852.
— ANANCHYTIS,	*d'Orbigny.*	Paléont. Franç. terr. Crétacés, t. vi, p. 131, pl. 826, 1853.
— GRANULOSUS,	*Forbes.*	Morris Catal. of Brit. Foss., 2nd ed., p. 73, 1854.
— ANANCHYTIS,	*Desor.*	Synops. des Échin. Foss., p. 345, pl. xxxix, figs. 7—9, 1857.
— —	*Coquand.*	Bull. Soc. Géol. France, 2e sér., tom. xvi, p. 1010, 1860.
— —	*Cotteau.*	Échinides du Dép. de la Sarthe, p. 237, pl. li, fig. 2—5, 1860.
— GRANULOSUS,	*Schluter.*	Foss. Echinoderm. des nördlichen Deutschlands Verh. d. Nat. Vereins der Rheinl. und Westphal., Jahrg. xxvi, Folge iii, Band vi, p. 251, 1869.

Diagnosis.—Test regularly cordate; upper surface in one variety depressed, in another more elevated. Primary tubercles large and conspicuous on each side of the anteal sulcus, which is wide and deep; posterior border narrow and obliquely truncated.

Dimensions.—This Urchin grows to a considerable size. The fine figured specimen is two inches and seven tenths of an inch in length, two inches and four tenths of an inch in breadth across the widest part of the ambitus, and one inch and four tenths of an inch in height at the vertex. Other specimens have greater height in proportion to their breadth, or greater length in proportion to their width, and others are higher and more convex on the upper surface, or are flatter and more depressed throughout.

The French specimens collected in the Sarthe, according to Mons. Cotteau, vary much in their proportional dimension. *Var. major.*—Antero-posterior diameter 43 milli-

[1] Termed in error Cardiaster granulosus on the explanation of figs. 2 and 3, Plate LXIX.

mètres; transverse diameter 42 millimètres; height 26 millimètres. *Var. minor.*—Antero-posterior diameter 27 millimètres; transverse diameter 25; height 15.

Description.—This elegant Urchin has a regularly cordate ambitus. It is deeply channelled in front by the anteal sulcus, which has sloping walls, with angulated borders above, and a deep granulated channel below. The greatest breadth of the test is immediately behind the antero-lateral ambulacra; from this point it slopes gently towards the posterior border, which is very narrow, and slightly truncated downwards and inwards.

The upper surface is convex, very much rounded before, and declining gently behind. The under surface is very much depressed near the mouth, and slightly convex in the single inter-ambulacrum, which has a sinuous ridge along the middle line, with nodular elevations at each alternate angle. The vertex is nearly central. The anteal sulcus is deeply hollowed out from the summit to the mouth, especially at the ambitus, and is circumscribed laterally and superiorly by angulated carinæ. The single ambulacrum is lodged in the sulcus, and composed of very small round pores, separated by a granuliform elevation, and situated in a small, smooth, lanceolate fossa, very narrow above and expanded below. The pores are close together above, and widen as the plates become larger. There are about twenty-eight plates visible in a full-grown specimen. The antero-lateral ambulacra are subpetaloid in their upper part, and unsymmetrical, in consequence of the pores of each pair being wider apart in the outer row than in the inner, and, moreover, being united by a deeper groove. There are about twenty-four pairs of pores in the subpetaloidal portion. They are closely approximated, and those that are below widen out; the outer series is likewise slightly arcuated. In the postero-lateral ambulacra the two series are nearly similar, and there are about eighteen pairs of pores in the subpetaloid portion. There are about nine plates in each series in the dorsal portion of the lateral inter-ambulacral segments, and ten above the vent in the posterior segment. The infra-anal portion of the latter is composed of two series of five irregularly polygonal plates each. They are remarkable for presenting gibbosities at regular intervals. In the inferior portions of each postero-lateral ambulacrum there are seven plates in each series. These are polygonal, large, and elongated, and bear the pairs of pores, which are minute and oblique, close to their inner angles. The pores of the ambulacra around the mouth form an obscure star.

The surface of the plates is profusely covered with very fine granules, which observe a very regular arrangement among them. Two sets of tubercles of unequal size cover the plates at regular distances apart; the small tubercles, which are seated among the granules of the upper surface (fig. 2 *f*), and the large tubercles, which are perforated and crenulated, are seen on the upper surface around the apical disc, upon the middle of the single inter-ambulacrum, and upon the borders of the anteal sulcus (fig. 2 *e*). In the infra-marginal region and along the central space on each side of the sinuous ridge (fig. 2 *b*), they are large and conspicuous. Each of the large tubercles is elevated upon a boss

with a crenulated summit, on which is placed a perforated tubercle (fig. 2 *l*). Very fine, close-set, homogeneous granules are prolonged horizontally between the pairs of pores in the poriferous zones, and likewise fill up the anteal sulcus, which is completely deprived of primary tubercles (fig. 2 *e* and *d*).

The apical disc is narrow, solid, and elongated, and so closely covered with the small granules that its elements are concealed. In many specimens it is composed of four ovarial and five perforated ocular plates. The anterior ovarials are small, and the madreporiform tubercle is quite rudimentary. The postero-laterals are long, and separated from the antero-laterals by two perforated oculars, so that the three anterior ambulacra are rather widely separated from the two posterior ambulacra (fig. 2 *d*).

The vent opens very low down in the narrow, posterior, triangular border. The periprocte is widely oval, and surrounded by numerous small granules (fig. 2 *d*).

The marginal fasciole is more or less distinct in different specimens. It passes under the periprocte, and runs out upon the sides towards the convex portion of the ambitus. It is narrow, and free from intermingled tubercles (fig. 2 *g*), and it is only well seen in very good specimens.

The base is flat, and the mouth situated near the anterior border in a depression formed by the deep grooving of the anteal sulcus, where it turns round the anterior border (fig. 2 *b*, *e*). The peristome consists of a convex upper lip and a prominent under lip. A few tubercles make a radiate ornamentation about the upper lip (fig. 2 *b*).

Affinities and Differences.—*Cardiaster ananchytis* is well distinguished from its congeners by its cordiform outline dilated before and subangular behind, by its deep anteal sulcus deprived of tubercles, by the poriferous zones very unequal in the antero- and postero-lateral pairs, by the large tubercles which show themselves sparsely on the upper surface, and by the low position of the periprocte.

History.—Leske (1778) first figured an imperfect specimen of this Urchin under the name of *Spatangus ananchytis*, and Lamarck afterwards called it *Ananchytes cordata*. Goldfuss figured it under the name of *Spatangus granulosus*, and *S. orbicularis*. Mr. Samuel Woodward, in his 'Geology of Norfolk,' figured it as *Spatangus cordiformis*; and then succeeded the various changes of name which have been already noted in the synonymy of the species. It is, however, to M. d'Orbigny's quick perception that we are indebted for first identifying Leske's figure with the subject of this article.

Locality and Stratigraphical Position.—First identified as a British Urchin by Mr. S. Woodward, who stated that it was rare in the Upper Chalk at Harford Bridge, and common in the Medial Chalk at Swaffham and Thetford, Norfolk. General Portlock has found and described it as *Holaster æqualis* in the Chalk of Londonderry.

Foreign Localities.—It has been collected in France, where it is rare, at Château-du-Loir, Teiffe, Duneau, Villedieu, Sarthe; Tours, Indre-et-Loire; Lauquais, Dordogne; Meudon, Seine: at Ciply, Belgium; Langelsheim, Brunswick; Haldem, Westphalia, in North Germany: it is found in the Upper and Lower Senonian.

Genus—INFULASTER, *Hagenow* MSS., 1851.

CARDIASTER, *Forbes*. 1852.
INFULASTER, *Desor* (with diagnosis). 1858.
— ZITTEL. 1879.

Test narrow, oblong, of an irregular ovato-cordate form. Anterior half very much elevated, rising into a prominent vertex, situated nearly above the anterior border; the anteal sulcus narrow, deep, and directed obliquely downwards and backwards, with two prominent angular borders, which rise above the upper surface. Plates smooth, covered with very small granules; a few primary tubercles near the vertex and at the sides, and in the centre of the under surface; a sub-anal fasciole is seen only on some fine specimens.

INFULASTER EXCENTRICUS, *Rose*. Pl. LXX, fig. 1, *a*—*k*.

SPATANGUS EXCENTRICUS, *Rose*. Woodward's Geol. of Norfolk, p. 27, pl. i, fig. 5, 1833.
CARDIASTER EXCENTRICUS, *Forbes*. Ann. Nat. Hist., 2nd series, vol. vi, p. 443, 1850.
— — *Forbes*. Mem. of Geol. Surv., decade iv, pl. x, 1852.
— — *Morris*. Catal. of Brit. Foss., 2nd ed., p. 73, 1854.

Diagnosis.—Test long, ovato-cordate; upper surface considerably elevated anteriorly and declining much to the posterior border; anteal sulcus deep, narrow subvertical; vertex very excentric; posterior border obliquely truncated, forming a triangular space, in which the periprocte occupies the upper angle.

Dimensions.—Antero-posterior diameter one inch and eight tenths of an inch; transverse diameter one inch and four tenths of an inch; height one inch and three tenths of an inch. These are the measurements of the large specimen figured in Pl. LXX, most kindly given to me by my friend the late Mr. Rose many years ago for this work.

Descriptions.—This singular Urchin has long been one of the greatest rarities of the Norfolk Chalk. When viewed in profile it presents the singular form seen in Pl. LXX, fig. 1 *c*; the high vertex nearly overhangs the anterior border, and the upper surface slopes away at an angle of 30° towards the posterior border which is truncated obliquely downwards and outwards, and imparts another odd feature to the test.

The dorsal surface is very high anteriorly (fig. 1 *c*), and the walls of the anteal sulcus rise nearly perpendicularly to the highest part of the body (fig. 1 *d*, *e*) immediately in front of the apical disc (fig. 1 *a*). From the point of its greatest elevation the upper surface gradually declines nearly in a straight line (fig. 1 *c*, *i*), forming a long sub-carinated ridge, which extends to the upper part of the posterior border (fig. 1 *d*), at about half the height of the test at the vertex. On each side of the ridge the upper surface slopes away rapidly (fig. 1 *d*), but the sides are rounded, and, in the antero-lateral regions, tumid (fig. 1 *e*). The posterior border forms a triangular space (fig. 1 *c*, *d*, *i*); which is obliquely truncated, and has the periprocte opening in its upper angle surrounded by a circle of tubercles two rows deep (fig. 1 *d*).

The under surface is convex in the antero-posterior, and transverse diameters, so that the under surface of the body is gently rounded in all directions; on the cheeks at the base a few primary tubercles are observed (fig. 1 *b*), and on the plastron another grouping of like tubercles is placed.

The single ambulacrum is lodged in the deep anteal sulcus, but the poriferous zones are scarcely discernible in good specimens. The lower half of the depression is rounded and covered with minute granules, among which no indications of pores can be seen with a hand magnifier; in the upper third they are small, indistinct, and closely set together, and are best seen where the uppermost portion of the area curves backward to meet the apical disc (fig. 1 *a*, *c*). Here we see a few pairs of small round pores, arranged in a vertical series, and the single ambulacrum articulating with the disc a little in advance of the antero-lateral ambulacra; these are placed very far forward and extend over the most tumid part of the sides of the test (fig. 1 *c* and *i*). The pores are very small (fig. 1 *a*). Forbes counted on a large specimen thirty pairs of pores in these rows between the apex and the margin; in my figured specimens only twenty can be identified. The avenues or poriferous zones are at the surface of the test, and the pairs of pores of the outer rows are a little wider than the inner one. The postero-lateral ambulacra are even less conspicuous (fig. 1 *c*, *d*); they diverge greatly from the antero-laterals, and form together a very acute angle. Their uppermost portion consisting of closely-set pores. On their posterior portions the pairs of pores become very indistinct.

The apical disc is small, narrow, and elongated (fig. 1 *k*). There are four perforated ovarial plates in the middle, and five very small perforated ocular plates at the summits of the areas; all the parts of the disc are very solid and firmly joined into the other elements of the test.

The mouth is situated near the anterior border (fig. 1 *b*) at the point where the anteal sulcus terminates, it therefore lies in a depression. It is a small opening with a round or transversely oblong peristome; the anterior lip is smooth, and the posterior more developed.

The vent is situated in the upper third of the truncated posterior border (fig. 1 *d*). The periprocte is vertically oval and of large size (fig. 1 *d*); its upper half is surmounted

by an arch of small tubercles, three tiers or more in depth, whilst the lower surface of the border is closely covered with small granules, among which a few small tubercles scattered here and there are seen.

The body-plates of the test are throughout covered with very fine close-set granules, and amongst these several small tubercles are disposed, from six to nine on each plate; at fig. 1 *f*, eight plates from the sides of the test have been carefully drawn and enlarged three diameters; in order that this arrangement on their surface, which is clearly demonstrable in good specimens, may be shewn, for on these only can the structure be discerned.

The plates on the margins of the anteal sulcus are thickly studded with large primary tubercles (fig. 1 *c*, *e*), which are raised on bosses with crenulated summits, and surmounted by perforated tubercles (fig. 1 *g*). The areolæ around the bosses are encircled by granules; tubercles similar to these in form and structure are seen on the cheeks of the shell, and a few are extended along the sides and on the central plates of the rounded base (fig. 1 *b*).

Forbes described the fasciole as "distinctly marked, passing under the vent and continued on each side, even over the cheeks." Some indications of this fasciolar track were drawn by my artist, who noted his impression in fig. 1 *h*; but I have seen nothing that I would call a fasciole, such as we observe in Hemiasters, Micrasters, &c., in any of the forms that have come under my examination.

Locality and Stratigraphical Position.—This remarkable Urchin, with which I know nothing to compare, was first observed by my old friend Mr. C. B. Rose, of Swaffham, and communicated by him to Mr. Samuel Woodward, in whose 'Geology of Norfolk' it was first figured from specimens collected from the Upper and Medial Chalk of Norfolk.

Affinities and Differences.—*Infulaster excentricus*, Rose, very much resembles *Infulaster Hagenowi*, Borchards, collected from the White Chalk of Staffin, in the Island of Wollin, Pomerania. A model in wax was communicated to Professor d'Orbigny by Herr von Hagenow, in 1851, without any other indication of publication. A comparison of specimens would alone enable the observer to decide on the affinities and differences of the German as compared with the Norfolk form; seeing that one of the specimens given me by Mr. Rose very much resembles *Infulaster Hagenowi*, Borchards.

INFULASTER ROSTRATUS, *Forbes*. Pl. LXX, figs. 2, *a*—*f*; 3 *a*.

Diagnosis.—Test much compressed on the sides; anteal sulcus long, deep, and narrow, its sides rising high into a beak; dorsal surface curved and carinated; posterior border obliquely truncated, bent in upper third; sub-anal fasciole, well defined, and extended on the flanks.

As I have been able to obtain only fragments of this Urchin, too imperfect for description, I shall transcribe the account which my late esteemed colleague Professor Edward Forbes, F.R.S., gave of it in the 'Memoirs of the Geological Survey' decade iv, p. 3, 1852.

"For some time," says Forbes, "I was under the impression that this extraordinary and anomalous little Urchin, of which specimens were kindly communicated by Dr. Bowerbank, Mr. Wetherell, and Mr. Woodward, was the young of the *Cardiaster excentricus*, different as its outline is. The series of specimens of various sizes of the latter shown me by Mr. Rose convinces me that it is necessary to regard this beaked and *Neæra*-like form of *Cardiaster* as distinct. All the examples are impressed with the same peculiarities. The number submitted to me has been seven, including fragments; and in addition to those lent for examination are two fine specimens, one of them nearly entire, found by Mr. Cockburn, in the Chalk-with-Flints, at Bostal Heath, near Plumstead, and generously presented by that gentlemen to the Museum of Practical Geology.

"The striking feature of this form is the rhomboidal profile which it exhibits in consequence of the obliquity of the anteal and posteal truncations, both inclining forwards at considerable angles (fig. 2 *a*—*e*). The anteal ambulacral sulcus is very deep, long, and narrow; it rises obliquely to a great height in consequence of the elevation of the apical disk upon a sort of beak (fig. 2 *e*). The genital plates are assembled just below its summit, which is notched by the turning over, as it were, of the anteal furrow. The details of the lateral ambulacra, in consequence of their being completely plane and very obscure, can with difficulty be distinguished; the rostrum bends forward slightly in its upper part. The summit of the back is more or less sharply carinated, and declines rapidly with a faint concave curve, until it terminates in the summit of the very oblique and rapidly declining posterior truncation, in the uppermost part of which, at rather less than the total height of the body, is the anus, placed at one end of a groove. The whole of the dorsal surface of the test is covered with granules interspersed with scattered minute tubercles, which become more numerous on the slightly tumid cheeks. The fasciole is strongly and distinctly marked, and passes from beneath the anus over the cheeks. The base is flattened, and except on the ambulacral spaces is strongly tuberculated. The mouth is very small and far forward."

Dimensions.—The largest specimen measured in length at the base, eight twelfths of an inch; in breadth, six twelfths of an inch; and in height, ten twelfths of an inch at the anteal sulcus.

Locality and Stratigraphical Position. — In the Chalk-with-Flints of Kent and Norfolk.

Genus—HOLASTER, *Agassiz*, 1839.

Synonym—SPATANGUS, *Auct.*

The test has an oval or cordiform figure, more or less convex at the upper surface, and, in general, flat at the under surface.

The pairs of antero- and postero-lateral ambulacral areas are apetaloidal, superficial, and lanceolate; they are widely apart below, and join each other above.

The poriferous zones are formed of elongated pores (always those in the external rows), disposed by simple pairs, very much separated and regularly superposed on each other, between the ambitus and apical disc. The ambulacrum, or single anterior area, is always lodged in a shallow central sulcus; its pores are very minute and resemble those of the lateral areas. The ambulacral summit is central or subcentral.

The apical disc is solid and elongated; its elements consist of four perforated ovarial plates and five perforated oculars. The genital plates are disposed in pairs, and the anterior are separated from the posterior pair by a pair of ocular plates being interposed between them.

The posterior border is narrow and more or less truncated, and the periprocte, always marginal, opens in general in the upper part of this region. The mouth-opening is situated near the anterior border in a slight depression, and the peristome is transversely oval and imperfectly bilabiate. There are no fascioles on any part of the test.

The shell is very thin, and the surface of the plates is uniformly covered with a very fine granulation; tubercles, more or less developed, appear in irregular order among them. Granules attaining their largest size, in the form of tubercles, appear upon the plates of the inter-ambulacral areas, and on those of the basal region, and this is more especially so in *Holaster Trecensis*, Leym. The ambulacral areas have, however, fewer tubercles than the other areas. The Holasters appertain to the Cretaceous Rocks, and form leading fossils in certain stages of the same; they are most abundant in the Upper Greensand and Lower Chalk, one species only being special to the White Chalk.

There seems to have been an unnecessary amount of confusion in the synonymy of some of the species, arising it would appear more from the copying of names than from the inspection and comparison of the specimens themselves.

In the British Islands we find: *Holaster lævis*, De Luc, in the Upper Greensand and Lower Chalk; *Holaster obliquus*, Wright, in the Upper Greensand and Lower Chalk; *Holaster suborbicularis*, Defrance, in the Chloritic Marl and Lower Chalk; *Holaster lævis*, var. *planus*, Mant., in the Upper Greensand, Lower Chalk, and lower portion of Upper Chalk; *Holaster subglobosus*, Leske, in the Chloritic Marl and Lower Chalk; *Holaster Trecensis*, Leym., in the Lower Chalk; *Holaster pillula*, Lamk., in the Upper Chalk.

HOLASTER LÆVIS, *De Luc.* Pl. LXXII, fig. 1 *a—f.*

SPATANGUS LÆVIS,	*De Luc.*	Cat. Collection, Berne Mus.
ANANCHYTIS CARINATA,	*Lamarck.*	Animaux sans Vertèbres, t. iii, p. 26, 1816.
SPATANGUS LÆVIS,	*Brongniart.*	Descr. Géol. des Environs de Paris, pp. 97 et 399, pl. ix, fig. 12, 1822.
— NODULOSUS,	*Goldfuss.*	Petref. Germaniæ, Band i, p. 149, pl. xlv, fig. 6, 1826.
— —	*Blainville.*	Manuel Actinologie, p. 204, 1834.
— —	*Desmoulins.*	Études sur les Échinides, p. 410, 1837.
HOLASTER LÆVIS,	*Agassiz.*	Descr. des Échinid. Suisses, t. i, p. 17, pl. iii, figs. 1—3, 1839.
— TRANSVERSUS,	*Agassiz.*	Ibid., t. i, p. 18, pl. iii, figs. 4—5, 1839.
— SUBORBICULARIS,	*Agassiz.*	Ibid., t. i, p. 21, pl. iii, figs. 11—13, 1839.
— SANDOZ,	*Agassiz.*	Ibid., t. i, p. 11, pl. ii, figs. 1—3, 1839.
— LÆVIS,	*Agassiz.*	Catal. Ectyp. foss. Mus. Neoc., p. 1, 1840.
— NODULOSUS,	*Agassiz.*	Ibid.
— SUBORBICULARIS,	*Agassiz.*	Ibid.
— —	*Morris.*	Catal. of British Fossils, p. 54, 1843.
— NODULOSUS,	*Morris.*	Ibid., p. 54, 1843.
— PLANUS,	*Morris.*	Ibid., p. 54, 1843.
— LÆVIS,	*d'Orbigny.*	Paléont. Franç., Ter. Crét., t. vi, p. 83, pl. 812, 1853.
— TRANSVERSUS,	*d'Orbigny.*	Ibid., p. 88, pl. 819, 1853.
— CARINATUS,	*d'Orbigny.*	Ibid., p. 104, pl. 818, 1853.
— LÆVIS,	*Renevier.*	Mém. Géol. sur la Perte-du-Rhône, p. 49, 1855.
— —	*Pictet.*	Traité de Paléontologie, 2nd ed., t. iv, p. 192, pl. xciii, fig. 3, 1857.
— CARINATUS,	*Pictet.*	Ibid., t. iv, p. 192, 1857.
— LÆVIS,	*Desor.*	Synopsis, p. 339, 1858.
— —	*Lory.*	Descr. Géol. du Dauphiné, p. 339, 1860.
— CARINATUS,	*Lory.*	Ibid., p. 350, 1860.
— —	*Cotteau.*	Échinides de la Sarthe, p. 195, pl. xxi, figs. 3—5, 1860.
— —	*Cotteau.*	Échinides Foss. de l'Yonne, t. ii, p. 249, pl. lxix, figs. 6, 7, 1865.
— —	*Geinitz.*	Elbthalgebirge in Sachsen i, p. 84, pl. xx, fig. 5, 1871.
— LÆVIS,	*De Loriol.*	Échinol. Helvetique Ter. Crét., p. 319, pl. xxvii, figs. 1—5, 1873.

Diagnosis.—Test oval, cordiform, slightly grooved before, and narrowed a little behind; largest diameter in the middle of the postero-lateral inter-ambulacra. Upper surface in general depressed, sometimes elevated and convex. The middle of the single

inter-ambulacrum (occasionally only) more or less elevated into a carina; under surface flat; peristome near the anterior border. Periprocte oval, situated in the upper part of a small truncated posterior border. Ambulacral summit subcentral, a little nearer the anterior border.

Dimensions.—Antero-posterior diameter one inch and a half; transverse diameter one inch and four tenths; height eight tenths of an inch. These are the dimensions of the average number of adult specimens obtained from the Upper Greensand of Wiltshire.

Description.—The body of this Urchin has a very regular figure, of a cordato-ovate shape, larger before and tapering behind, the largest transverse diameter being across the middle of the postero-lateral inter-ambulacra. The anteal sulcus is very shallow, and the anterior border only slightly depressed; the posterior border is narrow and obliquely truncated a little downwards and inwards.

The upper surface is in general elevated and convex (Pl. LXXII, fig. 1 *b*, *c*, *d*, *e*), and some specimens have the posterior half of the test a little more ridged, and the middle line forming a blunt carina, which has been erroneously considered a specific character by several authors (fig. 1 *c*, *d*).

The ambulacral areas are wide, apetaloid, and disjoined at the summit; the antero-lateral pair are arched backwards and forwards in their upper thirds (fig. 1 *b*), and the postero-lateral pairs slightly bent in the opposite direction (fig. 1 *b*). The single ambulacrum (fig. 1 *b*, *e*) is lodged in a wide, shallow anteal sulcus, the depression from which vanishes in the upper half of its length (fig. 1 *e*), so that the convexity of the dorsal surface is almost complete (fig. 1 *b*). The poriferous zones are narrow, the pores small, closely set in pairs, placed near each other above, and wider apart as they descend the sides. At the under surface the ambulacral areas are large and smooth, and quite superficial. The pores in the single ambulacrum are extremely small, and seen only in very good specimens.

The apical disc is narrow and elongated (fig. 1 *b*). The genital plates, four in number; are arranged in pairs, and between the anterior and posterior pairs one pair of the five ocular plates is interposed by aposition of the discal elements. The apices of the ambulacral areas are disjoined, as seen in fig. 1 *b*.

The base is very flat (fig. 1 *a*), and the ambital border forms an acute angle. The mouth-opening is lodged near the anterior border, in a depression of the test formed by the arching round the angle of the anteal sulcus. The peristome has an oval figure, slightly elongated transversely.

The vent opens at the posterior truncated border, always low down, near the base (fig. 1 *d*). The anal area is a very small, slightly hollowed-out space, the periprocte is oval in a vertical direction, and has a well-defined border.

The surface of all the plates is covered with an extremely fine abundant microscopic granulation, which is preserved in patches on different parts of good specimens;

in those from the Upper Greensand it has entirely disappeared, whilst on some specimens from the Lower Grey Chalk and the Chloritic Marl, its true character may be studied. Fig. 1 *f* shows an enlarged portion of a test, in which the granules existed with several of the primary tubercles interspersed at irregular intervals in the midst of the granulation. Many of the tubercles are raised on finely crenulated bosses, which support small perforated tubercles, accurately drawn in fig. 1 *f*.

Affinities and Differences.—The general form of the test varies much in this species, being more or less depressed or elevated in different examples; still the other characters, which may be considered as specific, remain very permanent in all these variations. The examples collected from the Grey Chalk near Folkestone, and from the Lower Chalk of Sussex, are in general larger and better preserved than the small typical specimens collected from the Upper Greensand at Chute Farm, Wilts. The Chalk specimens have likewise retained many of the large primary tubercles surrounded by patches of the granulated surface, and specimens collected from our Lower Chalk are absolutely identical with a specimen I have from the Craie Chloritée of Cap-le-Hève, near Rouen.

After a careful comparison between the tests of *Hol. lævis* and those of *Hol. carinatus*, and good figures of *Hol. transversus* and *Hol. marginatus*, I agree with my learned friend, Monsieur De Loriol,[1] that they in reality are all so many varieties of *Hol. lævis*, grown under different physical conditions, which have changed only some of the external characters of their original form, but left the essential and specific ones untouched. De Loriol has examined likewise the original example of the true large *Hol. Sandoz*, Agass., contained in the Museum of Zurich, with other examples of the collection of Monsieur Du Bois de Montpéreux, found by him in the Upper Greensand of Souaillon (Neuchâtel), and De Loriol affirms that *Hol. Sandoz* is only a very large and very fine specimen of *Hol. lævis*. Mons. De Loriol unites also *Hol. Trecensis*, Leymerie, with *Hol. lævis*. In Pl. LXXIV, fig. 2, I have given a very good figure of this species, and in page 324 have entered fully into this subject when describing its affinities. *Holaster lævis* differs from *Hol. planus*, Mantell, in some particulars. In *Hol. planus* the test is larger, more oblong and less cordate, and the ambulacral summit subcentral nearer the anterior border; the upper surface is flat and declines very little towards the posterior border, which is only slightly truncated to form an anal area, in the upper part of which the vent opens. *Hol. lævis* resembles likewise *Hol. suborbicularis* in some points of structure, but differs so widely in others that I must refer to my article on that species, and to that on *Hol. subglobosus*, for the affinities and differences existing between them.

Locality and Stratigraphical Position.—The small figured specimen I collected from the Upper Greensand at Chute Farm, Wilts, where it is very common. The tests are so much covered over with adhering sand particles that it is rare to obtain a good specimen. I have collected this species likewise from the Grey Chalk near Folkestone, and from the Lower Chalk, near Lewes, Sussex.

[1] 'Echinologie Helvetique,' p. 324, 1873.

HOLASTER OBLIQUUS, nov. sp., *Wright*. Pl. LXXVIII, fig. 1, *a*—*e*.

Diagnosis.—Test oblong, slightly cordate, greatest width across the anterior third, gradually diminishing in size to the posterior border, which is narrow and obliquely truncated; ambulacral summit excentral near the junction of the anterior with the middle third, upper surface convex and sloping downwards to the posterior margin; anal opening in the upper part; periprocte elliptical; area narrow and inclined downwards and inwards. Base rounded; mouth-opening near the anterior border; anteal sulcus shallow and inclined downwards and inwards; peristome small, transversely oval, unilabiate, and situated in a depression.

Dimensions.—Antero-posterior diameter two inches; transverse diameter one inch and three tenths; vent above the base seven tenths of an inch.

Description.—This rare Urchin has an oval outline; its greatest width is posterior to the antero-lateral ambulacral areas. From this part of the ambitus it tapers obliquely inwards towards the narrow posterior border. The upper surface is convex and the ventral summit, near the apical disc, is situated about the junction of the anterior with the middle third, and to this point all the ambulacral areas converge; from the disc to the posterior border the upper surface inclines obliquely downwards and forms a long slope towards the anal area. The antero-lateral ambulacra are short, straight, apetaloid, and lanceolate, and pass straight upwards from the ambitus to the disc. The postero-lateral ambulacra are straight, lanceolate, and apetaloid; they are much larger than the anterior pair from the excentral position of the summit. The poriferous zones are narrow and superficial; the pores small, and placed in pairs; forty pairs exist between the disc and the ambitus, and below that line they become invisible.

The apical disc is a small, narrow, oblong body, of which the elements are so closely soldered together that the sutures are obliterated.

The mouth-opening is small, and situated at a short distance from the anterior border in a depression formed by the incurving of the anteal sulcus. The peristome is small and transversely oval, and is placed near the junction of the first with the second fourth part of the total basal length of the shell.

The vent opens in the upper part of the posterior border; the anal area is very narrow, and the oval periprocte is situated high up in this space, where the convex portion of the long, obliquely-sloped back bends over the truncated portion of the posterior border.

The surface of the plates is covered with a close-set miliary granulation, which is beautifully preserved in a specimen from the Upper Greensand of Wiltshire. On the larger plates a few small tubercles are developed without much order in their arrangement. Six to eight such tubercles are seen upon many of these plates.

Affinities and Differences.—This species resembles, in many traits of structure, *Holaster lævis*. It is readily distinguished from that species by the ambulacral summit being much more excentral, which occasions a much longer slope between the apical disc and the posterior border, and a greater obliquity of the upper surface of the test; the antero-lateral ambulacra are shorter and straighter, and the postero-lateral pair much longer. The anteal sulcus is likewise shallower, and the posterior border much narrower. The rotundity and smoothness of the test, and the width and shallowness of the anteal sulcus form a marked difference between it and *Holaster suborbicularis*, and the same characters serve to separate it very distinctly from *Holaster subglobosus*.

Locality and Stratigraphical Position.—This Urchin appears to be rare. I have only seen three specimens; two of these were collected from the Lower Chalk near Folkestone, and the third was obtained from the Upper Greensand at Chute Farm, near Warminster, Wilts. I have compared this Urchin with a large number of Holasters from the Chalk of France and Switzerland, in the cabinet of my friend M. De Loriol; and it is easily distinguished from all its congeners by the excentral position of the apical summit, and the long sloping declension of the posterior two thirds of the upper surface. The specific name *excentricus* was at first suggested for this species, but as we have the *Infulaster excentricus* from the Cretaceous Rocks it was better to adopt *obliquus* as indicative of the obliquity of the upper and posterior surfaces of the test, in order to avoid any confusion regarding this new form, which I have now described and figured for the first time.

HOLASTER SUBORBICULARIS, *Defrance*. Pl. LXXIV, figs. 1 *a*—*e*.

SPATANGUS SUBORBICULARIS,		*Defrance*. MS., 1821.
—	—	*Brongniart*. Descrip. géol. Paris, p. 85, pl. v, fig. 5, 1822.
—	—	*Blainville*. Mém. d'Actinologie, p. 204, 1834.
HOLASTER	—	*Agassiz*. Prodrom. d'une Monogr., p. 16, 1836.
—	—	*Desmoulins*. Études sur les Éch. Foss., p. 400, 1837.
—	—	*Deshayes*, in Lamarck, 2nd ed., An. sans Vert., t. iii, p. 334, 1843.
—	—	*Sismonda*. Mém. géol.-zool. Echin., p. 8, 1843.
—	—	*d'Orbigny*. Paléontol. Franç., Ter. Crétacés, t. vi, p. 93, pl. 814, figs. 6, 7; pl. 815, 1853.
—	CENOMANENSIS,	*d'Orbigny*. Ib., p. 111, pl. 819, figs. 7—12, 1853.
—	SUBORBICULARIS,	*Desor*. Synopsis des Echin. Foss., p. 340, 1858.
—	—	*Cotteau*. Échinides de la Sarthe, p. 198, pl. xxxiii, figs. 1—6, 1860.

Diagnosis.—Test oblong, cordiform, rounded and deeply grooved before, contracted

and truncated vertically behind; superior surface elevated and convex on both sides, with a well-marked carina extending from the apical disc to the posterior border; the inferior surface much depressed before, and on each side of the mouth more or less elevated along the region of the plastron, and presenting alternate protuberances and depressions there, so that the greatest height of this species is about the posterior third of the test. Ambulacral summit excentral anteriorly; vent large, situated high up in the anal area.

Dimensions.—Antero-posterior diameter one inch and a half; transverse diameter one inch and three tenths of an inch; height nine tenths of an inch. I have several moulds of this species collected from a siliceous rock in Dorsetshire, which measured more than the figured specimen, obtained from the Chloritic Marl near Chard, and here drawn as our type because its shell is well preserved with many important details of its structure *in situ*. I have two large specimens of this Urchin from the Cap de la Hève. The largest measures two inches and six tenths in the antero-posterior diameter, two and a half inches in the transverse diameter; and one inch and two tenths in height; the second specimen measures two inches and four tenths in length, two inches and three tenths in breadth, and one inch and four tenths in height, so that when we reduce these measurements for comparison with those of the figured specimen, we find the proportions are nearly the same as relates to length, breadth, and height throughout.

Description.—This is a very neat, oblong, cordiform Urchin; the round anterior border is deeply grooved by the anteal sulcus, the widest part of the body is behind the anterior ambulacrum, and from that point backwards the ambitus contracts into the posterior border, which is vertically truncated to form the anal area (fig. 1 *e*).

The antero-lateral ambulacra curve gently up to the disc, and the postero-lateral pair are nearly straight in their course (fig. 1 *a*). The poriferous zones consist of pairs of pores, which are distant from each other below, and approximate above; in some of the larger specimens the pores are oblong below and round above. The anteal sulcus is very deep, extending from the mouth to the apical disc; it is bordered by elevations of the test, which form two carinæ on the sides of the sulcus (fig. 1 *a*, *d*). On these several large tubercles are arranged. The single ambulacrum occupies the middle of the sulcus; its avenues consist of very small pores, which are only visible with the aid of a lens. The three anterior ambulacra converge around the front of the disc, at a considerable distance from the posterior pair, which converge at the hinder part thereof (fig. 1 *a*).

The test is very thin, and the inter-ambulacral areas consist of very wide plates (fig. 1 *c*); their surface in both areas is closely covered with a very fine microscopic granulation, in the midst of which a number of small tubercles, nearly equal in size, are uniformly spaced out upon all the surface of the test. On the sides of the anteal sulcus, and on the cheeks and plastron at the base the tubercles are much larger; they are all raised on bosses with crenulated summits, and are perforated and surrounded by a smooth circular zone, defined by an outer circle of granules (fig. 1 *b*, *d*).

The apical disc is narrow and elongated; its elements consist of four perforated genital plates, on the right anterior of which the small madreporiform tubercle rests between the anterior and posterior pair; two ocular plates are interposed; the single ocular is seen at the summit of the single ambulacra, and the two posterior oculars at the summits of the hinder pair; the elements of the disc are closely united together, and the surface of the plates covered with fine granules.

The vent is large, and opens at the upper part of the anal area immediately below the carina (fig. 1 *e*). The periprocte is elliptical, with a well-defined margin acuminated at both extremities, and having the lower part of the border hollowed out (fig. 1 *e*).

The mouth is transversely oblong, placed near the anterior border in a depression formed by the anteal sulcus. The peristome is transversely oblong (fig. 1 *b*), and is rounded before, with a thickened projecting lip behind. Around the aperture are several pairs of round ambulacral pores arranged in a stellate figure (fig. 1 *b*).

Affinities and Differences.—This Urchin was long a puzzle to palæontologists, and we are indebted to d'Orbigny for having removed the confusion that existed, and for proving that Defrance's Urchin figured by Brongniart was the true type of the species. The English specimens are small, and resemble the Urchin described as *Holaster Cenomanensis*, d'Orb., which, however, is only a small variety of *Hol. suborbicularis*. M. Cotteau is disposed to unite this species to *Cardiaster fossarius*, Bennet, an opinion in which I cannot concur, as I feel satisfied that, if my learned friend had before him good type specimens of *Card. fossarius*, he would readily distinguish the differences between that Urchin and *Hol. suborbicularis*. Putting aside the question of the lateral fasciole, which I have never seen in *Card. fossarius*, the other features of the test are sufficiently distinct to show the differences which exist between them (see Pl. LXVIII).

In *Holaster fossarius* the shell is shorter and broader than in *Hol. suborbicularis*. The anteal sulcus is deeper, and retains its depth from the mouth to the disc, whereas in *Hol. suborbicularis* the sulcus vanishes above the anterior border, and leaves the upper surface smooth and undepressed. The carinæ on each side of the sulcus are more prominent and much sharper in *Hol. fossarius* than in *Hol. suborbicularis*, and the avenues of pores in the antero-lateral ambulacra are wider apart and more petaloid; whilst the base is flatter and the plastron less prominent in *Hol. fossarius* than those parts are in *Hol. suborbicularis*.

Locality and Stratigraphical Position.—This Urchin abounds in the bed of Chalk with green grains intervening between the Upper Greensand and Chalk-Marl. It is found likewise plentifully in the Chalk-Marl itself, and more rarely in the Lower Chalk. It has been collected in nearly all the English Counties in which these beds are found, but has not been observed in Ireland.

The Foreign Distribution.—Villers-sur-Mer, Vaches-Noires (Calvados); Montagne St.-Catherine près Rouen; Fécamp (Seine-Inférieure); Fourneaux, la Madelaine

(Eure); Laubressel, Sainte-Parre près Troyes (Aube); Fourrain, Seigneley, Yonne; Sancerre (Cher); Cassis (Bouches-du-Rhône); Vit près Castellane (Basses-Alpes); Bidart près Biarritz (Basses-Pyrénées); Palarea (Nice); Altmann (Appenzell); Quedlinburg, Prussia; North Germany, &c. In France it has been collected from the zone of *Acanthoceras Rhotomagense*, Brong., and in strata with *Scaphites æqualis* in Conde, Sarthe, which is precisely the same zone from which our English specimens have been collected.

HOLASTER LÆVIS, *var.* PLANUS, *Mantell.* Pl. LXXII, fig 2, *a—f;* Pl. LXXIX, fig. 1 *a*, *b*.

SPATANGUS PLANUS, *Mantell.* Geology of Sussex, p. 192, pl. xvii, figs. 9—21, 1822.
HOLASTER PLANUS, *Agassiz.* Prodrom. Mém. Soc. de Neuchâtel, t. i, p. 183, 1835.
— — *d'Orbigny.* Paléontol. Française, Ter. Crét., t. vi, pp. 116, 821, 1853.
— — *Desor.* Synopsis des Échinides, p. 342, 1858.

Diagnosis.—Test cordate, widest across the middle third, gradually diminishing in width to the posterior border, which is narrow and slightly truncated, anterior border a little depressed by the anteal sulcus. Ambulacral summit subcentral, upper surface convex, gently declining all round towards the ambitus; periprocte in the upper part of the anal area. Under surface flat, plastron prominent, mouth-opening near the border in a small depression, peristome transversely oval and bilabiate. Surface of the test smooth.

Dimensions.—Antero-posterior diameter two inches; transverse diameter one inch and eight tenths; periprocte above the base line seven tenths of an inch.

Description.—This Urchin has a cordate outline, and is widest anteriorly, its greatest transverse diameter being immediately behind the antero-lateral ambulacra; from this point it tapers gently to the posterior border, which presents a narrow truncation. The upper surface is convex, and the vertical summit with the apical disc is subcentral; to this point all the ambulacral areas converge (Pl. XXII, fig. 2 *b*). The antero-lateral pair are short, slightly bent, apetaloid, and lanceolate, they pass obliquely up the sides of the test. The poriferous zones are narrow and superficial, the pores small and placed in pairs; there are forty pairs of holes in each of the avenues above the ambitus, which are entirely invisible below; the postero-lateral pair are equally oblique and lanceolate, and their avenues of pores the same. In the figured specimen there are thirty pairs in each avenue. The single ambulacrum is lodged in a wide, shallow anteal sulcus which only slightly depresses the anterior border and entirely disappears in the upper half of its length (fig. 2 *a*, *b*, *d*).

The apical disc is small, long, and narrow; and its elements are so closely welded together that I have failed to detect the sutures which divide them (fig. 2 *b*).

The under surface is moderately flat about the cheeks and side border; it is elevated in the middle by the prominence of the plastron, and the path of the postero-lateral areas along the base is shown by a wide, smooth surface on each side of the central elevation (fig. 2 *a*).

The mouth-opening is small, situated a short distance from the border in a depression formed by the incurving of the anteal sulcus. The peristome is transversely oval, and placed about the junction of the first with the second fourth of the total basal length of the test (fig. 2 *a*).

The posterior border is very narrow, the anal area small, and the vent opens in its upper part; the oval periprocte is situated high up in this space, near the point where the convex part of the back bends over towards the truncated portion of the posterior border (fig. 2 *e*).

The surface of the plates is covered with a microscopic, close-set, miliary granulation, beautifully preserved and shown in some of the specimens derived from the Grey Chalk. On the larger plates a few small tubercles are arranged without much order, from six to eight of these may be counted upon each of the plates (fig. 2 *b*).

Affinities and Differences.—This species resembles some of the large forms of *Hol. lævis*, from which it differs very little; the ambulacral summit is slightly subcentral, which makes the direction of the ambulacral areas nearly uniformly quinque-radiate on the upper surface, as seen in fig. 2 *b*. The anteal sulcus is shallow, the posterior border narrow, and the position of the periprocte in the anal area is much the same in *Hol. planus* as in *Hol. lævis*. The rotundity and smoothness of the test, and the width and shallowness of the anteal sulcus in *Holaster planus* form marked differences between it and *Hol. suborbicularis*, with which it has sometimes been confounded, and the same characters serve to establish the differences between *Hol. planus* and *Hol. subglobosus*.

Locality and Stratigraphical Position.—This species is said to characterise a well-marked zone of the Lower Chalk at Lewes and Dover, and I have specimens collected from the Medial Chalk at Swaffham, Norfolk, sent by my old friend the late Mr. C. B. Rose. It occurs also in the chalk with flints (in lower portion of the Upper Chalk) near Lewes. The specimen (Pl. LXXIX, fig. 1) from the Collection of the Rev. Thos. Wiltshire, F.G.S., shows that the species was gregarious.

Many geologists express surprise that several species of Echinides are recorded by me as having been found in the Grey Chalk, Lower Chalk, Chloritic Chalk, and Upper Greensand. There can be no doubt about the fact of the presence of this species therein; other forms also have often occurred to me when noting the distribution of species in these beds. It may be suggested whether some artificial divisions, in the natural groupings of the strata, have not been made on petrological rather than on palæontological grounds. If this conjecture should turn out to be correct then the Lower

Chalk and Upper Greensand may be bracketed together, and not separated by a hard-and-fast line as at present.

HOLASTER SUBGLOBOSUS, *Leske*, sp. Pl. LXXIII, figs. *a*—*h*.

SPATANGUS SUBGLOBOSUS,	*Leske.* Add. ad Kleinii Disp. Echin., p. 240, pl. liv, figs. 2, 3, 1778.
ECHINUS SUBGLOBOSUS,	*Linné.* Gmelin's Systema Natura, p. 3198, 1789.
— —	*Lamarck.* Encyl. Method., Zoophytes., pl. 157, figs. 7, 8, 1791.
SPATANGUS SUBGLOBOSUS,	*Lamarck.* Animaux sans Vertèbres, t. iii, p. 33, 1816.
— —	*Deslongchamps.* Encycl. Method., Zoophytes, p. 689, 1824.
— —	*Goldfuss.* Petref. Germaniæ p. 148, pl. xvii, fig. 4, 1826.
— —	*Blainville.* Zoophytes, Dict. Sc. Nat., t. lx, p. 185, 1830.
— HEMISPHÆRICUS,	*Phillips.* Geol. of Yorkshire, p. 91, pl. i, fig. 16, 1835.
HOLASTER SUBGLOBOSUS,	*Agassiz.* Prodrome, Mém. Soc. Nat. de Neuchâtel, t. i, p. 183, 1836.
SPATANGUS SUBGLOBOSUS,	*Desmoulins.* Études sur les Échinides, p. 398, 1837.
HOLASTER SUBGLOBOSUS,	*Agassiz.* Descr. des Échin. foss. de la Suisse i, p. 13, pl. ii, figs. 7—9, 1839.
— ALTUS,	*Agassiz.* Ibid., pl. iii, figs. 9—10, 1839.
— SUBGLOBOSUS,	*Römer.* Petref. der norddeutschen Kreidegebirges, p. 34, 1840.
HOLASTER SUBROTUNDUS,	*Sismonda.* Echin. Foss. del Cont. di Nizza, p. 5, 1843.
— SUBGLOBOSUS,	*Morris.* Catal. of British Fossils, p. 54, 1843.
— —	*Agassiz & Desor.* Catal. raisonné des Échinides, p. 133, 1847.
— —	*A. Gras.* Oursins Fossiles de l'Isère, p. 63, 1848.
— —	*Sorignet.* Oursins de l'Eure, p. 67, 1850.
— —	*Forbes*, in Dixon's Geol. of Sussex, p. 341, pl. xxiv, fig. 2, pl. xxix, fig. 1, 1850.
— —	*Bronn.* Lethæa Geognost., p. 204, pl. xxxi, fig. 2 *a*, *a*, 1852.
— —	*Forbes.* Mem. Geol. Surv. Decade iv, pl. vii, 1852.
— —	*Quenstedt.* Handbuch der Petref., p. 591, pl. l, fig. 14, 1852.
— —	*d'Orbigny.* Paléont. Franç., Terr. Crét., t. vi, p. 97, pl. 816, 1853.
— —	*Leymerie et Cotteau.* Catal. des Echin. Foss. des Pyrénées; Bull. Soc. Géol. de France, 2me série, t. xiii, p. 350. 1856.
— —	*Strombeck.* Glieder. des Planers, in N.-W. Deutschland; Zeitschr. der Deutschen geol. Gesellsch., vol. ix, p. 415, 1857.

Holaster subglobosus,		*Cotteau et Triger.* Éch. foss. de la Sarthe, p. 202, pl. xxxiii, figs. 7, 8, 1860.
—	—	*Lory.* Descr. du Dauphiné, pp. 350, 367, 1860.
—	—	*Dujardin et Hupe.* Suites à Buffon, Échinodermes, p. 592, 1862.
—	—	*Strombeck.* Die Kreide bei Lüneburg; Zeitsch. deutsch. Gessell., 1863.
—	—	*Cotteau.* Catal. des Échin. de l'Aube, p. 39, 1865.
—	—	*Ooster.* Synopsis des Échin. Foss. des Alpes Suisses, p. 96, 1865.
—	—	*Heer.* Die Urwelt der Schweiz, p. 205, 1865.
—	—	*Cotteau.* Échin. Foss. de l'Yonne, t. ii, p. 244, pls. lxviii, lxix, 1866.
—	—	*Renevier.* Notice sur les Alpes vaud., p. 171, 1867.
—	—	*Bucaille.* Foss. Cénomaniens de Rouen, p. 6, 1867.
—	—	*Jaccard.* Descr. Géol. du Jura vaud. et Neuchat., p. 120 1869.
—	—	*Greppin.* Descr. Géol. du Jura Vernois, p. 143, 1870.
—	—	*De Loriol.* Échinologie Helvetique, p. 330, pl. xxvi, figs. 11—14, 1873.

Diagnosis.—Test of a subglobular form, very nearly as broad and as high as it is long. The upper surface regularly convex, sometimes a little elevated at the summit; a well-marked carina rises on the middle of the single inter-ambulacrum; the under surface more or less convex; the ambitus rounded and inflated; the ambulacral summit slightly excentral in the anterior direction; posterior border narrow, obliquely truncated downwards and inwards; vent in the upper part of the area.

Dimensions.—From a number of specimens collected by the Geological Survey from different localities, the following table of comparative dimensions of six specimens, selected on account of their differences, was prepared by my colleague the late Professor Edward Forbes, to illustrate the variation in the proportions of this species.

No.	Locality.	Stratum.	Length.	Breadth.	Height.
1	Dover	Chalk-Marl	$2\frac{4}{12}$	$2\frac{5}{12}$	$1\frac{10}{12}$
2	Do.	Lower Chalk	2	2	$1\frac{3}{12}$
3	Chaldon	Chloritic Marl	$1\frac{11}{12}$	$1\frac{11}{12}$	$1\frac{4}{12}$
4	Do.	Do.	$1\frac{11}{12}$	2	$1\frac{2}{12}$
5	Do.	Do.	$1\frac{6}{12}$	$1\frac{5}{12}$	$1\frac{1}{12}$
6	Do.	Do.	$1\frac{7}{12}$	$1\frac{6}{12}$	$1\frac{2}{12}$

Varieties.—There is a curious variety of this species, in which the anteal sulcus is

deeply impressed into an almost acute furrow. Professor Forbes found this abnormal form at the junction of the Chalk-Marl and Upper Greensand, near Abinger, in Surrey; and there is a very fine and large specimen of it in the British Museum Collection.

I have a large specimen of this Urchin in my cabinet, collected from the Pläner at Rheten, which measures in length $2\frac{6}{10}$th inches, in breadth $2\frac{6}{10}$th inches, and in height 2 inches.

Description.—This well-known Urchin of the Lower Chalk has long been familiar to collectors of Cretaceous fossils. It was very fairly figured by Leske in his 'Additamenta ad Klein.,' and has kept its place well in the list of synonyms ever since. Lamarck, however, appears to have mistaken this fossil, as he refers to Leske's figure a specimen from Grignon près Versailles, where the formation is Tertiary; so either an error in the species, or a mistake in naming the locality, has been committed.

The test is large, subcircular, or cordiform, almost as wide as it is long (fig. 1 *a*); the body is dilated and slightly grooved anteriorly, subacuminated and obliquely truncated posteriorly (fig. 1 *b*, *c*). The upper surface is convex and the ambitus uniformly inflated (fig. *e*, *d*); the base is likewise convex, except near the anteal depression for the mouth (fig. 1 *b*). The ambulacral summit is nearly central (fig. 1 *a*).

The antero-lateral ambulacra are lanceolate, apetaloid, and curve gently backwards and inwards, forming a flat Gothic arch over the anterior surface of the test (fig. 1, *a*).

The postero-lateral pair are lanceolate, apetaloid, and straight (fig. 1, *d*). The poriferous zones in the two pairs of areas are very much alike. The pores of each pair are set well apart, and connected by a furrow, but below the middle and in the wider plates they become smaller and closer. There are about forty pairs of holes in each avenue of the anterior pair, and a lesser number in the avenues of the posterior pair (fig. 1, *g*, *h*).

The single ambulacrum has a special structure. It is lodged in the anteal sulcus, which is wide and shallow. Its surface is concave and smooth, and it is linear-lanceolate. The apices of the three anterior ambulacra converge at some distance from those of the posterior pair (fig. 1, *a*), which meet near each other at the posterior portion of the apical disc. The poriferous avenues of the single ambulacrum are very narrow, the pores quite microscopic, and fewer in number than in the pairs (fig. 1, *h*).

The inter-ambulacral areas (fig. 1 *a*, *c*) are formed of large wide plates, which have their surface covered with a close-set microscopic granulation; and arising in their midst are a series of three or four irregular horizontal rows of primary tubercles. I have given a most accurate drawing of this structure in fig. 1 *g*, which shows two inter-ambulacral plates and a portion of an ambulacral area magnified three times; in fig. 1 *h* a portion of the single ambulacrum magnified three times is shown; and in fig. 1 *i* is given a view of three primary crenulated and perforated tubercles magnified, with the circles of granules surrounding the areolæ and filling in the intervening space with moderately sized granules.

The apical disc is much elongated (fig. 1 *a*, *f*); it is composed of four perforated genital plates; the right anterior plate has its surface covered with the madreporiform body, and is separated from the posterior pair by two of the perforated ocular plates, which are interposed between the anterior pair, and produce the length and narrowness of the disc; all the elements of the disc are closely soldered together, and densely covered with microscopic granulations, a few solitary tubercles only are seen in their midst.

Where the anteal sulcus curves round the ambitus (fig. 1 *e*) a depression is formed at the base (fig. 1 *b*), in which the mouth is situated; the peristome is a small, transversely oval, bilabiate aperture; the upper lip is thickened and higher than the lower, and the buccal extremities of the poriferous avenues form an irregular stellate figure around the peristome (fig. 1 *b*).

The posterior border of the test is truncated obliquely downwards and inwards (fig. 1 *c*), and in some specimens slightly hollowed into a concave channel below the vent, which occupies the upper part of the anal area (fig. 1 *d*), in a position about half the height of the test. The periprocte is vertically of an elliptical figure (fig. 1 *d*), and its upper angle forms the termination of the dorsal carina which extends backwards from the disc to the border.

Affinities and Differences.—This Urchin is so well characterised by its specific features that it is not easily mistaken for any other. *Hol. cor-avium*, Lamk., has been ascertained by d'Orbigny's inspection of the type in the museum to be a siliceous mould of *Hol. subglobosus*; and *Hol. nasutus*, labelled by M. Agassiz in the museum, is only a specimen of *Hol. subglobosus* deformed by pressure.

Locality and Stratigraphical Position.—This Urchin abounds in the bed of Chalk with green grains intervening between the Upper Greensand and Chalk-Marl. It is found also plentifully in the Chalk-Marl itself and more rarely in the Lower Chalk. I have had many fine specimens from the Chloritic Marl near Chard, and from the Chalk-Marl near Lewes, in Sussex. The Chalk-Marl of Wiltshire and of Dorsetshire has yielded many specimens. This species, says Forbes, has not been found in Ireland.

Foreign Localities.—It is found at the Mountain Sainte-Catherine, near Rouen, Fécamp, and Havre, at Saint-Parre and Laubresel, near Troyes, Aube; with *Acanthoceras Rotomagense*, Brong., at Pourrain, and Seigneley, Yonne; Sancerre, Cher; Cassis, Bouches-du-Rhône; Bidart, near Biarritz, Basses-Pyrénées; Villers-sur-Mer, Calvados; Trinité, near Nice. In Switzerland, in the 'Etage Cénomanien,' Monsieur De Loriol records it from Sainte-Croix, Vaud.; Cheville, Valais; Ried, near Bienne, Berne; Summit of Sentis, Ebenalp, Sentis; Secalp, Appenzell, Yberg-Sil, Schwytz; Lac Saint-Point, Jura. In Germany, Goldfuss records it from Quedlinburg, Prussia; Neuwallmoden and Langelsheim, Brunswick.

HOLASTER TRECENSIS, *Leymerie*. Pl. LXXIV, fig. 2, *a*—*e*.

HOLASTER TRECENSIS,		*Leymerie*.	Mém. de la Soc. géol., p. 2, pl. ii, fig. 1, 1842.
—	—	*Agassiz*.	Catal. raisonné, p. 134, 1847.
—	PILLULA var. MAXIMA,	*Agassiz* and *Desor*.	Ibid., p. 135, 1847.
—	TRECENSIS,	*d'Orbigny*.	Prodrome 2, p. 269, No. 1161, 1847.
—	—	—	Pal. Franç., Ter. Crétacés, vol. vi, p. 101, pl. 847, 1853.

Diagnosis.—Test oblong, cordiform; upper surface very much elevated, rounded, and grooved before, tapering gently to a narrow truncation behind. Ambulacral summit nearly central; under surface very flat; mouth near the border. Vent in a small marginal anal area near the angle; upper surface covered with large tubercles, arranged without much regularity upon both areas.

Dimensions.—Antero-posterior diameter two inches and four tenths; transverse diameter two inches and four tenths; height one inch and five tenths.

Description.—The test is oval and cordiform, much inflated, and nearly as broad as long; enlarged and sinuous before, accuminated behind. The upper surface is much elevated and very convex, the outlines antero-posteriorly, as well as laterally, describing regular curves (fig. 2 *c*, *d*). The ambulacral summit is nearly central (fig. 2 *a*), where we find the apical disc, which is small, and shows four perforated genital plates. The central portions of the inter-ambulacra are rather prominent, which imparts an angular appearance to the ambitus (fig. 2 *d*). The base is very flat, with the exception of a slight prominence in the middle of the plastron, where we observe seven alternate elevations, with a connective zigzag ridge between (fig. 2 *b*). The anterior portion near the anteal sulcus is slightly depressed (fig. 2 *b*), where we find the mouth-opening, which is large, and transversely oval. The peristome is bilabiate; the anterior lip is depressed and convex, and the posterior elevated and prominent. The vent occupies the posterior border, and opens near the base; it is situated in a small triangular anal area, slightly excavated out of the border (fig. 2 *e*). The periprocte is longitudinally oval, placed under an angular projection in the median line, with two lateral ridges to divide the area from the ambital circumference (fig. 2 *e*).

The ambulacral areas are very feebly defined in this Urchin; the anterior single area is lodged in the sulcus; its poriferous zones are only slightly visible near the summit. The antero-lateral and postero-lateral pairs are narrowly lanceolate. The anterior pair curve slightly forwards, and the posterior pair are straight (fig. 2 *a*). The poriferous zones are formed of transverse oblong pores arranged in pairs, and the anterior is smaller than the posterior row; they extend half-way over the upper surface and sides, and disappear above the ambitus (fig. 2 *c*, *d*).

The tubercles are of two kinds; small tubercles, which are seen in the ambulacral

areas and on other parts of the test, and large tubercles, developed upon the inter-ambulacral plates without much order or regularity, and varying much in number in different specimens. These tubercles are perforated at the summit, and raised upon bosses with crenulated rims. The specimen I have figured shows this tubercular structure to perfection, but the majority of specimens want the profusion of large tubercles seen on the figured shell (Pl. LXXIV, fig. 2). Besides the tubercles just described, the surface of the plates is covered with microscopic granules which form circles around the base of the tubercles and crowd the spaces between them with a close-set granulation. It is only in well-preserved specimens, however, that this structure can be observed, and then only by the assistance of a lens.

Affinities and Differences.—This fine Urchin was well figured by the late Prof. Leymerie in 1842,[1] and afterwards by d'Orbigny in 1853.[2] I had been fortunate in procuring a very fine example of this Holaster from the Grey Chalk of Folkestone, and I desired my late friend Mr. Bone to make most accurate figures of it, which he has done, and given five beautiful drawings of the same in Plate LXXIV, fig. 2 *a*—*e*.

At first sight one naturally concludes that *Hol. Trecensis*, Ley., is a well-defined form, and fully entitled to specific rank, but a closer examination of the test, and a comparison of it with other fossils considered to be *Hol. carinatus*, weaken our faith in this belief. Characters at first sight thought to be specific appear to be evanescent. The size and number of the tubercles on the upper surface of *Hol. Trecensis*, for instance, are not constant, seeing that in some specimens they dwindle away, and in others almost disappear. Finally, the close identity of *Hol. Trecensis* with *Hol. carinatus*, from being a doubt, becomes a certainty. Now arises the next question, in what does *Hol. carinatus* differ from *Hol. lævis?* Failing to discover the specific differences which many eminent palæontologists have thought they saw in these different forms, we have at length arrived at the conclusion that my learned friend Mons. De Loriol came to, after a patient and exhaustive study of *Hol. lævis*, namely, that these three forms—*Hol. carinatus*, *Hol. Trecensis*, and *Hol. lævis*—are only varieties more or less defined of *Hol. lævis*, De Luc.

Locality and Stratigraphical Position.—The fine specimen figured in Pl. LXXIV, fig. 2, was collected from the Grey Chalk, near Folkestone, and I have several other large specimens from the Lower Chalk of Wiltshire and from the Medial Chalk, Swaffham, Norfolk.

Foreign localities.—Prof. Leymerie found his type specimen at Saint-Parre, near Troyes, Aube; it has been collected likewise at Mont Saint-Catherine, Rouen, Seine-Inférieure, with *Acanthoceras Rhotomagense;* and from the Chloritic Chalk in the environs of Saint-Croix, Vaud, Switzerland.

[1] 'Mém. de la Soc. géol. de France,' p. 5, pl. ii, fig. 1, 1842.

[2] 'Paléontologie Française, Ter. Crétacés,' tom. vi, pl. 847, 1853.

PLATE LXX.

Infulaster excentricus, *Rose.*

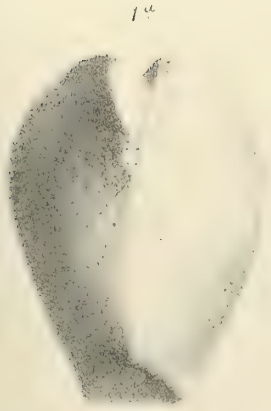
From the White Chalk of Norfolk.

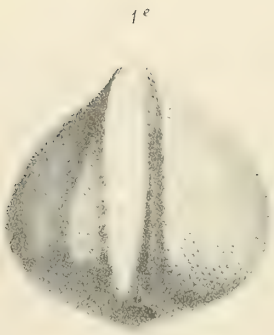
Fig. 1 *a*. Upper surface, natural size. My collection. (P. 305.)
b. Under do. do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Surface sculpture of interambulacral plates, magnified three times.
g. Primary tubercles and encircling granules, highly magnified.
h. Part of the cheek, with a portion of the fasciole do.
i. Details of test and apical disc as shown in a flint mould, natural size.
k. The apical disc, highly magnified.

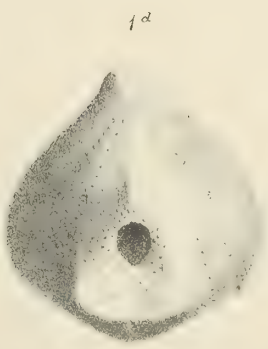
Infulaster rostratus, *Forbes.*

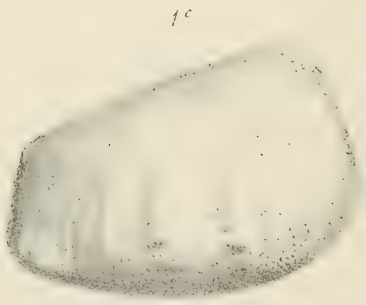
From the White Chalk near Plumstead.

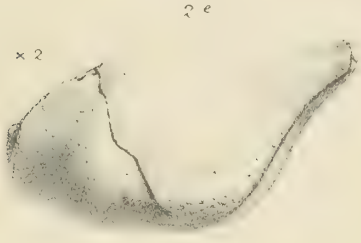
Fig. 2 *a*. Lateral view, natural size. Museum, School of Mines. (P. 307.)
b., *c*., *d*., *e*. Different views of a specimen from Chalk near Plumstead.
f. Part of the cheek and fasciole. Museum, School of Mines.
Figs. 3 *a*. Outline, partly restored, of a large specimen from Norfolk Chalk, in the late Mr. Rose's Collection.

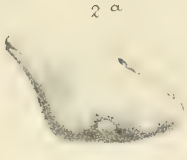












C.R. Bone del. et lith.

W.West & C° imp.

PLATE LXXI.

Cardiaster pillula, *Lamarck.*

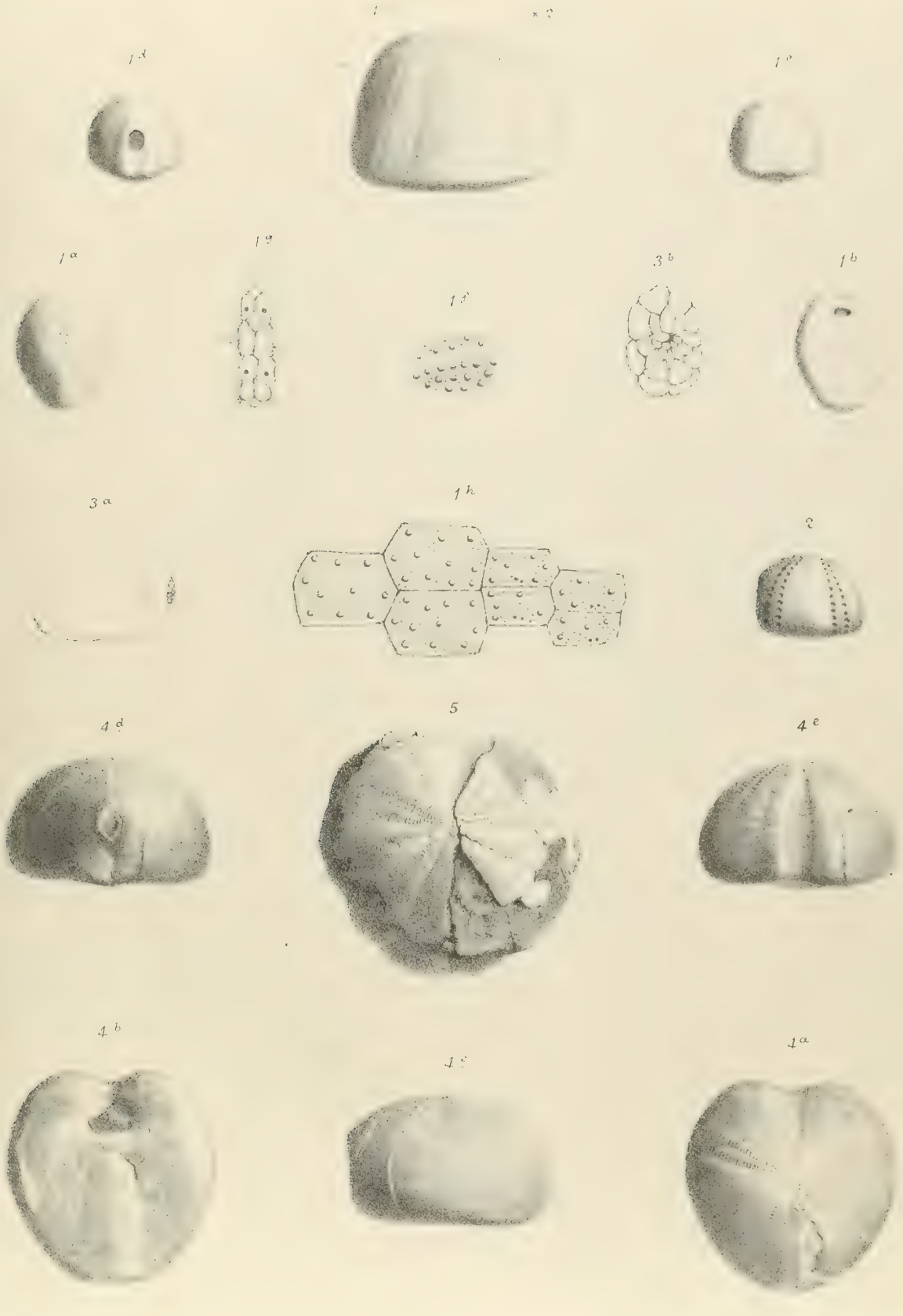
From the White Chalk

Fig. 1 *a.* Upper surface, natural size. Museum, School of Mines. (P. 325.)
b. Under do. do.
c. Lateral view, magnified two diameters.
d. Posterior border and periprocte, natural size.
e. Anterior do and anteal sulcus.
f. Part of the cheek with fasciole, magnified.
g. The elongated apical disc do.
h. Interambulacral plates, showing surface sculpture, highly magnified.
Fig. 2. Flint mould showing the poriferous zones.
Fig. 3 *a.* Flint mould of another specimen, showing position of the vent.
b. Anal plates for closing the periprocte.

Cardiaster Benstedi, *Forbes.*

From the Lower Greensand.

Fig. 4 *a.* Upper surface, natural size. My collection. (P. 293.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte, natural size.
e. Anterior do. and anteal sulcus do.
Fig. 5. Large specimen showing poriferous zone.



C.R. Bone del et lith.

W. West & Co. imp.

PLATE LXXII.

Holaster lævis, *De Luc.*

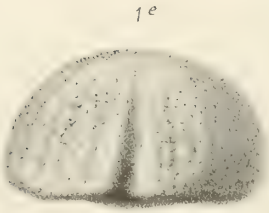
From the Upper Greensand.

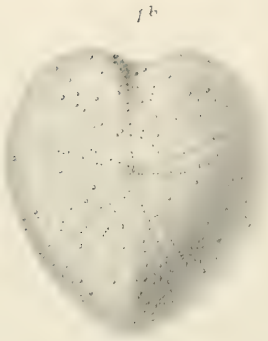
Fig. 1 *a*. Under surface, natural size. My collection. (P. 310.)
b. Upper do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Primary tubercles and granules, magnified.

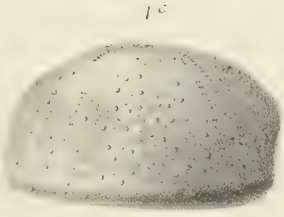
Holaster lævis *var.* planus, *Mantell.*

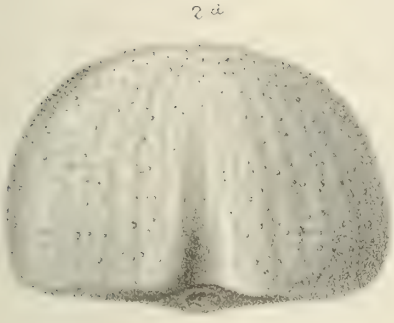
From the Lower Chalk.

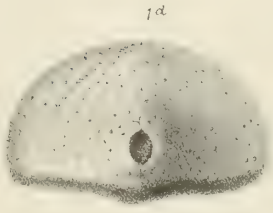
Fig. 2 *a*. Under surface, natural size. My collection. (P. 317.)
b. Upper do. do.
c. Lateral view do.
d. Anterior border and anteal sulcus.
e. Posterior do. and periprocte.
f. Poriferous zones, magnified.

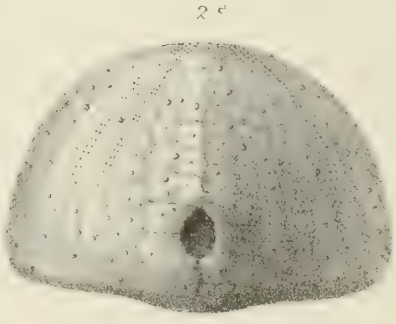


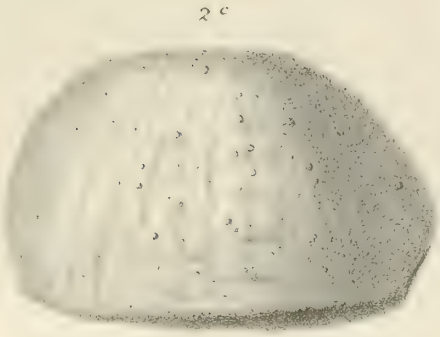












A. Gavan del. et lith

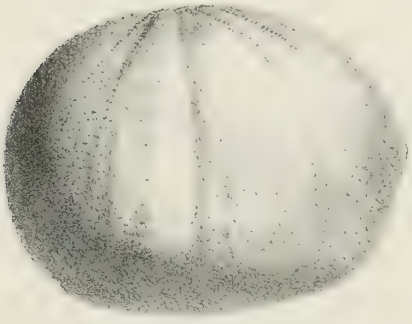
West Newman & Co imp

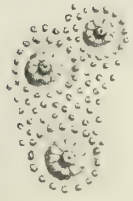
PLATE LXXIII.

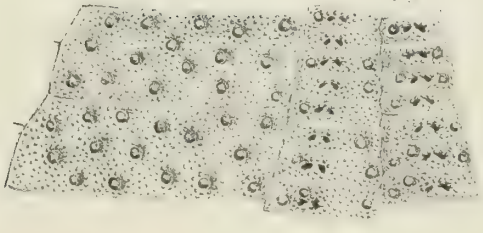
HOLASTER SUBGLOBOSUS, *Leske.*

From the Lower Chalk.

Fig. 1 *a*. Upper surface, natural size. My collection. (P. 319.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Apical disc, highly magnified.
g. Ambulacral and interambulacral plates, and poriferous zones, magnified three diameters, showing the regular surface sculpture.
h. Ambulacral area and poriferous zones, magnified three times.
i. Primary tubercles, with the scrobicular circles of granules highly magnified.







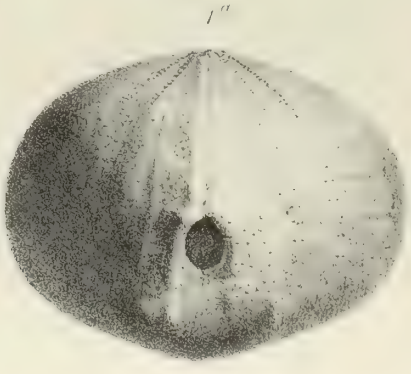


PLATE LXXIV.

HOLASTER SUBORBICULARIS, *Defrance.*

From the Chloritic Marl.

Fig. 1 *a*. Upper surface, natural size. My collection. (P. 314.)
b. Under surface do.
c. Lateral view do.
d. Anterior do. do.
e. Posterior do. do.

HOLASTER TRECENSIS, *Leymerie.*

From the Lower and Grey Chalk.

Fig. 2 *a*. Upper surface, natural size. My collection. (P. 323.)
b. Under do. do.
c. Lateral view do.
d. Anterior do. do.
e. Posterior border showing the position of the periprocte.

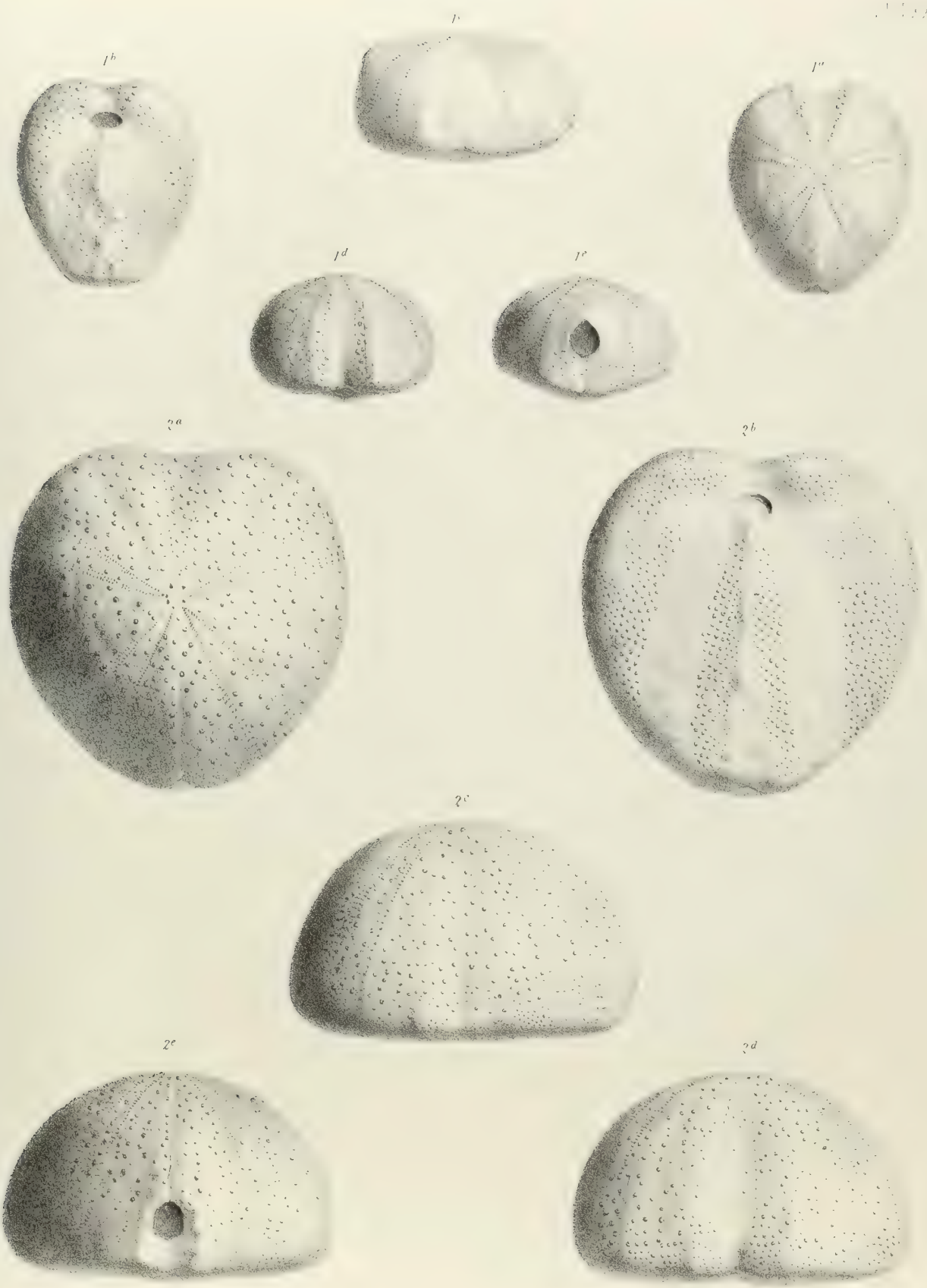

1a
1b
1c
1d
1e
2a
2b
2c
2d
2e

PLATE LXXV.

Echinospatagus Renevieri, *Wright.*

From the Lower Greensand, Shanklin Isle of Wight.

Fig. 1 *a.* Upper surface, natural size. Monsieur De Loriol's collection. (P. 285.)
b. Under do. do.
c. Lateral view do.
d. Primary tubercles, under surface.
e. Do. upper do.

Echinospatagus Quenstedtii, *Wright.*

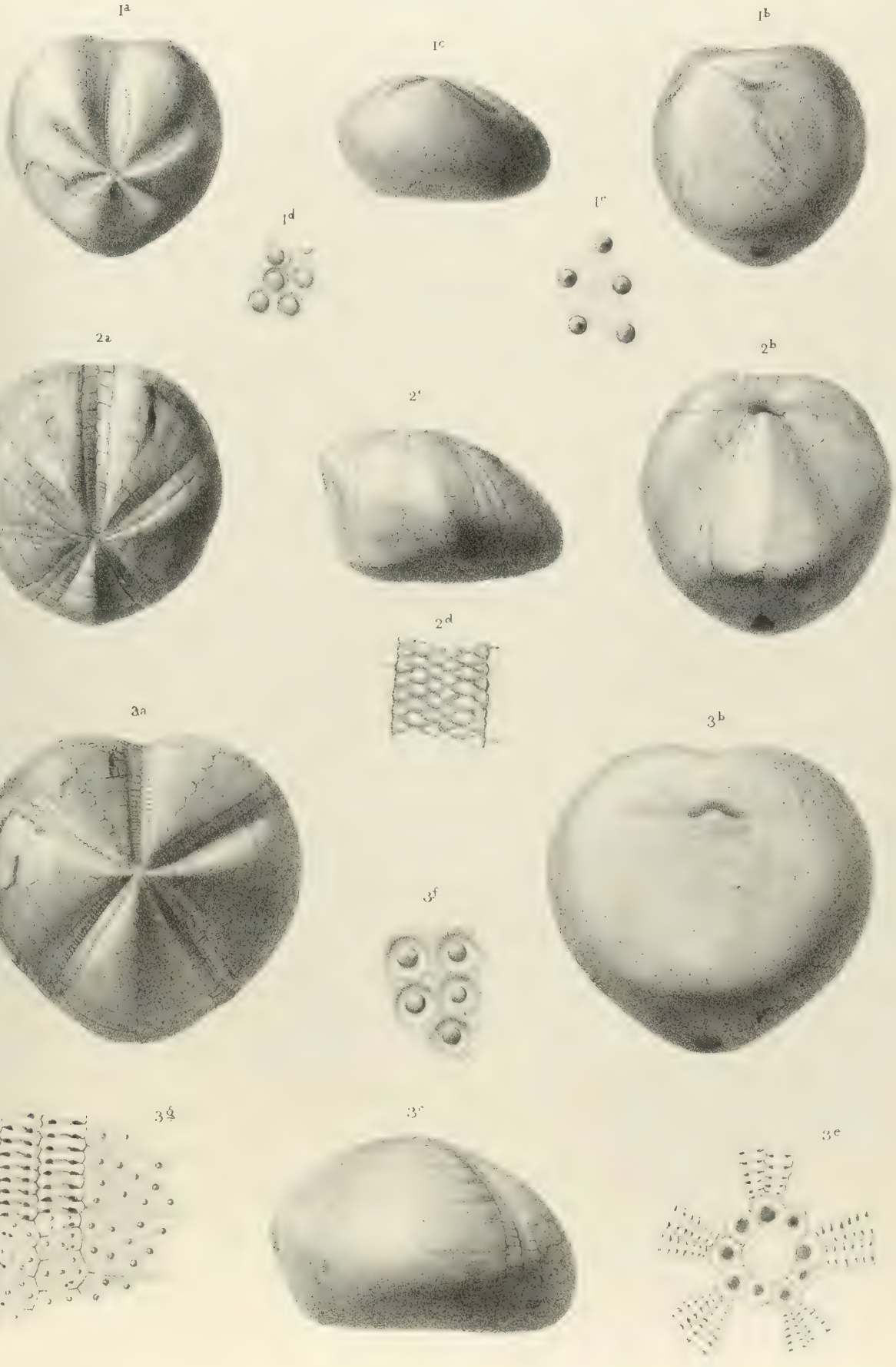
From the Upper Greensand, Wiltshire.

Fig. 2 *a.* Upper surface, natural size. My collection. (P. 286.)
b. Under do. do.
c. Lateral view do.

Micraster brevis, *Desor.*

From the Chalk of Corbières and Craie à Hippurites.

Fig. 3 *a.* Upper surface, natural size. My collection.
b. Under do. do.
c. Lateral view do.
e. Apical disc, and terminations of the ambulacra much enlarged.
f. Primary tubercles from the under surface, enlarged to show the deep areolæ and circles of granules.
g. Ambulacral area, poriferous zones, and interambulacral plates, enlarged three diameters, to show the structure of the surface sculpture of the test.
Fig. 2 *d.* Non-petaloid portion of the ambulacra.



G.L.Griesbach del et lith.

Hanhart imp

THE

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INSTITUTED MDCCCXLVII.

VOLUME FOR 1881.

LONDON:

MDCCCLXXXI.

MONOGRAPH

OF THE

BRITISH FOSSIL BRACHIOPODA.

BY

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VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; MEMBER OF THE GEOLOGICAL SOCIETIES OF FRANCE, BELGIUM, EDINBURGH, AND GLASGOW; FOREIGN MEMBER OF THE PROVINCIAL INSTITUTE OF FRANCE; OF THE LINNEAN SOCIETY OF NORMANDY; OF THE IMPERIAL MINERALOGICAL SOCIETY OF ST. PETERSBURG; OF THE IMPERIAL SOCIETY OF NATURALISTS OF MOSCOW; OF THE ROYAL ACADEMIES OF BELGIUM AND BAVARIA; OF THE ROYAL SOCIETY OF HOLLAND, HAARLEM; OF THE ROYAL SOCIETY OF LIÈGE; OF THE ACADEMY OF ST. LOUIS; OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; OF THE INSTITUTE OF ALBANY, UNITED STATES; OF THE ZOOLOGICAL SOCIETY OF VIENNA; OF THE PALÆONTOGRAPHICAL SOCIETIES OF BELGIUM AND OF SWITZERLAND; OF THE MALACOLOGICAL SOCIETY OF BELGIUM; HON. MEMBER OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE DUDLEY AND MIDLAND GEOLOGICAL AND SCIENTIFIC SOCIETY; OF THE NATURAL HISTORY SOCIETY OF GLASGOW; AND OF THE YORKSHIRE PHILOSOPHICAL SOCIETY, ETC. ETC.

VOL. IV.

PART IV.

DEVONIAN AND SILURIAN BRACHIOPODA THAT OCCUR IN THE TRIASSIC PEBBLE BED OF BUDLEIGH SALTERTON, IN DEVONSHIRE.

PAGES 317—368; PLATES XXXVIII—XLII.

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1881.

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ON THE DEVONIAN AND SILURIAN BRACHIOPODA THAT OCCUR IN THE TRIASSIC PEBBLE-BED OF BUDLEIGH-SALTERTON, NEAR EXMOUTH, IN DEVONSHIRE.

Before commencing the Devonian and Silurian Supplements it has been thought desirable to treat separately of a large series of Brachiopoda belonging to those periods, but of which the greater number of species have not hitherto been found in rocks *in situ* in Great Britain. These fossils occur in sandstone and quartzite boulders or pebbles that have been drifted from some distance, accumulated, and spread over a considerable tract of country in the neighbourhood of Budleigh-Salterton. The source of derivation of these pebbles is still a matter of speculation, but they were without doubt drifted during the Triassic period; and we propose to lay before our readers the present state of our knowledge on this difficult and interesting subject.

At page 355 of his work, 'The Student's Elements of Geology' (ed. 1871), Sir Charles Lyell gives the following well-known nomenclature of the Trias, the upper and lower divisions alone of which are represented in Great Britain.

German.	*French.*	*English.*
Keuper.	Marnes irisées.	Upper Trias—Saliferous Shale and Sandstone.
Muschelkalk.	Calcaire coquillier.	Middle Trias—wanting in England.
Bunter Sandstein.	Grès bigarré.	Lower Trias—Sandstone and Quartzose conglomerate.

The boulders, in which the species of Brachiopoda I am about to describe occur, vary considerably in shape and size, being both rounded and flattened; and at my request Mr. H. J. Carter, F.R.S., of Budleigh-Salterton, has kindly drawn up a detailed account of the different kinds of pebbles that occur in this now well-known locality. This will be found to convey all the information that could be desired.[1] It is, however, with the

[1] "The Cove of Budleigh-Salterton is about two and a half miles long, confronted by a narrow pebble beach, bordered by the sea on one side, and for the most part by high cliffs of the New Red Sandstone series, capped by a thin detrital layer of the flinty remains of the Cretaceous, which formerly overlaid it, on the other. The pebbles of this beach, which are derived from the sources just mentioned, are of all sizes below a foot in diameter; and from the prevalence of the south-west wind on this coast, they are chiefly gathered together at its eastern end, although kept from extending further on either side by the presence of reefs of New Red Sandstone conglomerate projecting into the sea.

"Looking at the cliff from the sea, we observe that it may be divided into three distinct portions,

sandstone and quartzite boulders alone that we have to deal. These, as observed by Mr. Carter, constitute the great bulk of the pebble-bed of the locality. Their position

each parallelly overlying each other, and also dipping steeply towards the east, viz. first (beginning from the west) a group of Red Clay strata; second, a thick stratum of Pebbles, which we shall henceforth call the 'Old Beach' (as their form and position bear evidence of its marine accumulation as much as does that of the accumulation now going on here, which, in contradiction, will be called the 'New Beach'), to which we shall now give our chief attention; and third, Red Sand strata.

"Beginning again from the west, the stratum of Pebbles may be seen in the cliff to cap Flagstaff Hill, which is about 300 feet above the level of the sea, and slopes downwards for about a mile to disappear under the New Beach, so that the rate of dip of these strata may thus be easily conceived. The pebble-bed is about fifty feet thick and subject, with the other strata, to slight faults here and there in its course; but it is not our business to deal with them here so much as with the form, position, size, and nature of the pebbles of which this stratum (which is said to extend twelve miles inland) is composed.

"The form of the pebbles is for the most part elliptical, or subcircular and compressed; and they lie with their long axes more or less parallel to the stratum; but they may be more or less globular according to the massiveness or hardness of the rock from which they originally came, In size they vary from a foot in diameter to immeasurable smallness, and in number are inversely proportioned in their largeness. The stratum, too, is often intercalated by small limited beds of sand.

"We may divide the pebbles of this 'Old Beach' into Plutonian or Igneous, Neptunian or Aqueous, and Pluto-Neptunian, respectively thus—

Plutonian.	*Neptunian.*	*Pluto-Neptunian.*
"1. Granitoid.	1. Quartzites of different degrees of fineness up to coarse.	
"2. Porphyroid.		1. Volcanic breccia.
"3. Volcanic.	2*a*. Grits or pudding-stone.	

"PLUTONIAN.

"1. *Granitoid.*—These are for the most part composed of a fine crystalline base embedding the same materials in larger portions, viz. hyaline Quartz, Felspar, and Hornblende. Of these three ingredients the crystals of Felspar are most striking, from their opaque pink colour and large size; next in size and regularity of form comes the Hornblende, and lastly the hyaline Quartz. Such pebbles I have found of all sizes, from nearly a foot in diameter downwards. The mineral combination mentioned may be found under different aspects—thus, the pink opaque Feldspar may be transparent, colourless, and glassy, or the Hornblende may be actinolitic, and the Quartz recrystallized in prisms, &c., but however much these changes, partly due to decomposition, as well as the relative form and nature of the ingredients, may give rise to varieties, they chiefly characterise the rock from which these pebbles were derived. Mica I have never seen, unless the glittering particles which equally characterise the Red Sandstone generally, as well as the pebbles of the old beach, is to be regarded as such. Opaque, white quartz pebbles from the granitoid rock are occasionally found charged with pellets of a light yellow, glistening, laminated mineral, which, from its softness and almost inflexibility, *empyrically* I should set down as talc, as well as the glistening particles just mentioned. Still an Avanturine pebble is not uncommon.

"2. *Porphyroid.*—Such are pebbles consisting of compact grey or reddish feldspathic base embedding round grains of hyaline quartz, and rhombic crystals of pink feldspar. Like the foregoing, the feldspathic, crystals may have other minerals embedded in them, but the staple composition of the rock is that mentioned. I never found pebbles of it more than six inches in diameter. Its local name is said to be 'Elvan Stone,' and it is also said that it occurs as dykes in the granitoid rocks of Dartmoor and Cornwall.

"3. *Volcanic.*—I would assign this name to dark, black, greenish pebbles whose composition appears

will be best understood from a glance at the sketch we here append from a drawing by Mr. W. Linford, of Exeter, who has devoted much time and study to this remarkable deposit and locality.

to be hornblendic, and whose texture is often so compact as to give it a jaspideous character and toughness equal to Lydian stone. It is most frequently veined with white quartz, and being often brecciated with angular fragments identical with the Granitoid and Neptunian pebbles respectively, will be more particularly described presently under the name of 'Volcanic Breccia.'

"NEPTUNIAN.

"1. *Quartzite.*—The material here is chiefly sand of various degrees of fineness, more or less mixed with grains of pink felspar and little particles of a glistening mineral, like talc or mica, cemented by a recrystallization of the quartz into a firm tough rock. The usual colour is grey, but it may be almost white, or yellowish, or ferruginous—red or variegated with mixture of these colours. The form here is also usually elliptical or subcircular and compressed, more so than in the Plutonic rocks, which, from their hardness, toughness, and massive unstratified structure have not yielded so much to attrition. Albeit there are pebbles of quartzite, which from its hardness are almost sometimes subglobular. In many there is a laminated structure bearing evident signs of stratification, which, together with the presence of organic remains, leaves no doubt that they come from the Neptunian or stratified formations. In size these pebbles also vary from a foot in diameter downwards.

"2. *Grits.*—This name I would apply to some coarse quartzites, such as are composed of grains varying in size from those which can be easily seen by the unassisted eye to those of which the coarsest puddingstone is composed. It is necessary, however, for the student not to confound such pebbles with similar ones that may be formed by an agglomeration of the contents of the New Red Sandstone. Those belonging to the Old Beach may vary in size from a foot in diameter downwards, like the quartzites.

"PLUTO-NEPTUNIAN.

"*Volcanic Breccia.*—Of this I have nothing further to state than that the pebbles of it are composed of angular portions of the Granitoid and Neptunian rocks, cemented together by the tough black jaspideous material already described as *Volcanic*. They are variously composed, vary in size from a foot in diameter downwards, and seldom present a compressed form from the extreme toughness of the binding material.

"*Relative proportions of the pebbles, as to amount, in the Old Beach.*—By far the largest proportion of the pebbles (that is, the *quartzites*) in the Old Beach in the cliff may be seen to have come from the Neptunian formation. Next to this come the black *volcanic* and the *volcanic breccia* pebbles, which may average one per cent. The granitoid are not unfrequent, nor are the porphyroid pebbles, but the latter, from the decomposing influence of the potash in the feldspar, may, from their whiteness and pulverulent state, be easily seen *in sitû*, where nothing but the grains of hyaline quartz will often be found to have remained intact.

"NEW BEACH.

"Of course the pebbles of the 'New Beach' are chiefly derived from the old one, together with the harder detritus of the New Red Sandstone and the flinty remains of the Cretaceous series which formerly rested upon it: all now more or less additionally rounded by attrition from the influence of the losses which are at present going on; wherefrom, also, portions of the clay-strata and fragments of bricks soon present exactly the same kind of compressed elliptical or circular form which characterises, for the most part, the pebbles in the 'Old Beach,' thus bearing evidence of the way in which the fragments of the latter received their form, and therefore the marine origin of the beach itself. All the pebbles found in the Old Beach

THE TRIASSIC CLIFF, BUDLEIGH-SALTERTON.

A. Broken Cliff. B. Flag-staff, West Down. C. Sherbrook Lake. D. Silurian and Devonian Pebble-bed. F. Red Marl and Sands. E. Budleigh-Salterton.

In vol. i, p. 61, 1797, of Polwhele's 'Devon' we find, so far as we are aware, the first published account of the pebbles that occur in the cliff and neighbourhood of Budleigh-Salterton. The author notices the respective dimensions, composition, and distribution of the pebbles, but makes no mention of any fossils.

Mr. Carter informs me that he must have been the first who detected organic remains in the quartzite boulders, for in 1835 he picked up a pebble[1] full of impressions and internal casts of a small *Orthis* (*O. Budleighensis*), and at the same time made a collection of the different kinds of pebbles, now in the Albert Memorial Museum at Exeter. In 1864 Messrs. Vicary and Salter gave an excellent account of the pebbles. In this communication Mr. Salter describes and figures eleven species of Brachiopoda, and refers them, as well as several species belonging to other classes, to the Lower-Silurian period. He suggests, also, in his description of three of them, viz. *Spirifera antiquissima*, *Sp. Davidsii*, and an unnamed *Rhynchonella*, that some of the pebbles containing these species may perhaps have had a Devonian origin. Mr. Salter says, also, that the mass of the Budleigh-Salterton fossils are Normandy types of the "May" Sandstone, that some belong to the "Grès Armoricain," that several of the species have been already named in France, and that some of the most conspicuous shells, though apparently not identified, are characteristic of both sides of the Channel. Had Mr.

are equally and proportionally found in the new one, excepting the *Porphyroid* pebbles, which, from their frequent decomposition *in sitû*, are seldom sufficiently hard enough to undergo the ordeal of the waves without entirely going to pieces; hence, specimens of this pebble are only occasionally met with in the New Beach. There are also a few pebbles of quartzite breccia in which the veining cement is not black; but here the fragments are of the same kind, showing that such pebbles must have come from Neptunian strata, which had been shattered by succession *in sitû*, and subsequently cemented by some of their own materials before they were finally broken up. Such specimens might be adduced to show that the quartzite pebbles are derived from Neptunian formations of different ages, but by far the most reliable evidence of this kind has been obtained from the nature of the organic remains that they contain; and this will be supplied by their palæontology.

"By far, also, the most prevalent and striking mineral of these pebbles is the pink opaque feldspar, both in the original Plutonian rocks and the Neptunian quartzites that have been derived from them."—(H. J. Carter, F.R.S., &c.)

[1] This fossiliferous pebble has been liberally deposited in my collection by Mr. Carter; and in April, 1863, it had been mentioned by him to Mr. Pengelly and others.

Salter been able to recognise in his so-named *Spirifera antiquissima* the well-known Devonian *Sp. Verneuilii* he would have been able to have asserted that pebbles of Devonian origin were in reality found associated with the Lower-Silurian ones. In another paper, published in 1864, he says that nearly thirty species of fossils have been already detected in the Budleigh-Salterton pebbles, all new to British geologists, and refers the pebbles and their fossils to the Lower Silurian, adding that the deposits from whence they had been drifted could not be far from our shores, as they contain French and not British species. Mr. Salter would, however, have been nearer to the truth, as to the age of the fossils, had he abided by the conclusions arrived at in his first paper.

Since 1797 a great deal has been published on the Budleigh-Salterton question, both at home and abroad; and to save repetitions I append, in a foot-note, a list of all the papers that are known to me as treating directly or indirectly of the subject.[1] These

[1] 1797. *Polwhele's* Devon, vol. i, p. 61.

1863. *Vicary & Salter.* On the Pebble-bed and Fossils of Budleigh Salterton—Quart. Journ. Geol. Soc., vol. xx, p. 283, pls. xv, xvi, xvii.

1864. *Salter.* On some points in Ancient Physical Geology, illustrated by Fossils from a Pebble-bed at Budleigh Salterton, Devonshire—Geol. Mag., vol. i, p. 5, July, 1864.

1864. *Pengelly.* The Denudation of Rocks in Devonshire—Trans. of the Devonshire Association for the Advancement of Science, Literature, and Art, vol. i, part iii, pp. 45–49, July, 1864.

1865. *P. B. Brodie.* On the Drift of Warwickshire—Brit. Assoc. Reports for 1865; Geol. Mag., vol. ii, p. 566, 1865; and Trans. Devon. Assoc., vol. ix, p. 223.

1865. *Pengelly.* The Red Sandstone Conglomerates and Marls of Devonshire—Annual Report and Trans. of the Plymouth Institution; Devon and Cornwall Nat. Hist. Soc.

1866. *Davidson.* British Silurian Brachiopoda—Pal. Soc.

1867. *Etheridge.* On the Physical Structure of West Somerset and North Devon—Quart. Journ. Geol. Soc., vol. xxxiii.

1869. *Davidson.* Notes on the Brachiopoda hitherto obtained from the Pebble-bed of Budleigh-Salterton—Exeter Meeting of Brit. Assoc., 1869; and Quarterly Journal Geol. Soc, vol. xxvi, p. 70, &c., 1869.

1869. *Etheridge.* On Budleigh-Salterton Pebble-bed—Discussion on the reading of Mr. Davidson's paper, Quart. Journ. Geol. Soc., vol. xxvi, p. 89.

1869. *E. Hull.* The Triassic and Permian Rocks of the Midland Counties of England—Memoirs of the Geol. Survey of England.

1870. *T. Tawney.* Fossils of the Budleigh-Salterton Pebbles—Geol. Mag., vol. vii, p. 141; and On the Occurrence of Fossils at Smuggler's Cave, Torquay—Trans. of the Devon. Association for the Advancement of Science, 1870.

1870–1872. *W. Whitaker.* List of Works on the Geology, Mineralogy, and Palæontology of Devonshire—Journal of the Royal Institution of Cornwall.

1872. *W. Linford.* On the Budleigh-Salterton Pebbles—Trans. Geol. Soc. of Edinburgh, vol. ii, part i, 1872.

1872. *C. W. Peach.* Notes on the Pebbles of Budleigh-Salterton—Trans. Geol. Soc. of Edinburgh, vol. ii.

1874. *W. Linford.* Notes on the Quarries at Caen and May, in Normandy—Rep. and Proc. of the

papers are of considerable interest, as they show how many differences in opinion have been entertained, and the numerous endeavours made to solve that most difficult question of the *situs* of the parent rocks whence this vast accumulation of boulders was derived. So like, indeed, are these pebbles to each other in external aspect, colour, and mineral composition, that the geologist could not separate those belonging to either of these geological periods were it not for the fossils that a very small proportion of them contain. These are, however, the exception, and not the rule, when the great bulk of

Tamworth Nat. Hist., Geol., and Antiquarian Soc., vol. i, part i, p. 41, &c. (Read to the Society in Nov., 1871, published in 1874.)

1874. *A. Wyatt-Edgell.* Notes on some Lamellibranchs of the Budleigh-Salterton Pebbles—Quart. Journ. Geol. Soc., vol. xxx, p. 45.

1875. *Whitaker.* List of Works on the Geology of Cornwall—Journ. of the Royal Institution of Cornwall, No. xvi.

1876. *W. A. E. Ussher.* On the Triassic Rocks of Somerset and Devon, part i—Quart. Journ. Geol. Soc., vol. xxxii, p. 367.

1877. *W. A. E. Ussher.* A Chapter on the Budleigh-Salterton Pebbles—Trans. Devonshire Assoc. for the Advancement of Science, vol. ix, p. 222, 1877.

1878. *W. A. E. Ussher.* The Chronological Value of the Pleistocene Deposits of Devon—Quart. Journ. Geol. Soc., vol. xxxiv, p. 449, August, 1878.

1878. *W. A. E. Ussher.* On the Chronological Value of the Triassic Strata of the South-western Counties—Quart. Journ. Geol. Soc., vol. xxxiv, p. 459.

1878. *Etheridge.* Discussion after the reading of Mr. Ussher's paper on the Chronological Value of the Triassic Strata, &c.—Quart. Journ. Geol. Soc., August, 1878.

1878. *W. Whitaker.* Ditto—Quart. Journ. Geol. Soc., vol. xxxiv, p. 469, 1879.

1878. *Prof. Hughes.* Discussion following the reading of Mr. Ussher's paper—Quart. Journ. Geol. Soc., vol. xxxiv, p. 470, 1878.

1878. *Pengelly.* The Gorran Beds and the Budleigh-Salterton Pebbles—Geol. Mag., new ser., vol. v, p. 238.

1878. *S. G. Perceval.* On *Orthis redux* in the Midland Bunter Pebbles—Geol. Mag., new ser., vol. v, p. 333; also two letters in the Exeter and Plymouth Gazette, August, 1877.

1878. *W. A. E. Ussher.* On the Mouth of the River Exe—Trans. of Devon. Ass. for 1878.

1878. *Townshend M. Hall.* Sketch of the Geology of Devonshire—White's History, Gazetteer, and Directory of the County, p. 64.

1878. *J. H. Jennings.* On the Origin of a Quartzite Boulder from the Bunter Conglomerate, Nottingham—Geol. Mag., new ser., vol. v, p. 239, 1878.

1879. *W. J. Harrison.* Fossiliferous Bunter Pebbles in the Drift—The Midland Naturalist, vol. ii, p. 283, Nov., 1879.

1879. *Pengelly.* On the Metamorphosis of the Rocks from Hope Cove to Start Bay—Dev. Assoc. Meeting at Ilfracombe, July, 1879, and Trans. of Devon. Assoc., 1879.

1879. *W. A. E. Ussher.* On the Triassic Rocks of Normandy—Quart. Journ. Geol. Soc., May, 1879.

1880. *Davidson.* On the Species of Brachiopoda that characterise the Grès Armoricain of Brittany and Normandy, together with a few Observations on the Budleigh-Salterton Pebbles—Geol. Mag., new series, vol. vi, p. 338, pl. x, August, 1880.

1880. *T. G. Bonney.* Notes on the Pebbles in the Bunter Beds of Staffordshire—Geol. Mag., decade ii, vol. vii, p. 404.

the deposit is considered; and they are found only occasionally by the men who break the pebbles for road-material, and for which they are well adapted on account of the hardness of their composition and their durability.

The fossils have been extensively collected during many years by Messrs. Vicary, W. Linford, Winwood, Wyatt-Edgell, Valpy, Carter, Pengelly, Box, and others, who, in the most liberal manner, forwarded for my examination and use every specimen of Brachiopod, as well as fossils of other classes, that had fallen into their hands. Thus, I have been enabled to give descriptions and figures of some forty species. I would therefore avail myself of the present opportunity to tender to those scientific friends, as well as to Messrs. Etheridge, McKennyHughes, Dr. Woodward, A. E. Ussher, Brodie, Whitaker, Perceval, Harrison, and others, my grateful thanks for the help and information they have so unreservedly imparted to me on this subject. Nor must I omit to thank in a similar manner M. Gaston de Tromelin, M. Lebesconte, M. Marie Rouault, and Prof. Morière, for the loan of very extensive series of Normandy and Brittany specimens bearing upon the subject of this Monograph, as well as for the valuable information they have liberally afforded me. I have thus been enabled to compare very minutely and carefully a series of French species, and upwards of a thousand specimens from sandstones and quartzite rocks *in sitû*; and these, in many cases, agree in every respect with those found in our sandstone and quartzite pebbles at Budleigh-Salterton.

Mr. W. Linford states in one of his papers that "the pebbles are scattered more or less over a district bounded on the east by the River Otter, and on the west by the Rivers Exe and Clyst—a width of country varying from five to ten miles, also extending from the coast on the south for twelve or thirteen miles north, viz. from the cliffs at Budleigh-Salterton to Straightway Head, where they thin off, and, it is believed, terminate at Fallaton, whither they have been traced." Near the village of Budleigh-Salterton, in the cliff, the pebble-bed attains a thickness of from eighty to ninety feet. It is also quite certain that at the time the Triassic waters were drifting these pebbles the land extended to a considerably greater distance in the Channel, for the action of the waves is continually carrying away large portions of the cliff, the whole shore being scattered with the pebbles washed out of it.

In 1869, and previously, while examining an extensive collection of the fossiliferous pebbles lent to me by Mr. Vicary, I was surprised to find that a large proportion of the fossils of the various classes, and especially of Brachiopoda, were of a Devonian type, and that no "mélange" of Silurian and Devonian forms did ever occur in the same pebble; every individual stone containing specimens or species belonging to one or to the other period. One of the most abundant forms was the well-known Devonian *Spirifer Verneuilii*, which was often found in the same pebble with other equally well-known Devonian species.

I also found that those pebbles that contained the "Grès Armoricain" species, viz.

Lingula Lesueuri, *L. Hawkei*, *L. Salteri*, and *Dinobolus Brimonti*, never contained any other forms; and that in the pebbles of the age of the "Grès de May" Caradoc species only occurred with *Orthis Budleighensis*, the most abundant form of that division of the Lower-Silurian formation. This opinion was subsequently confirmed by several competent observers, among whom we may name Messrs. Salter, Linwood, Wyatt-Edgell, Pengelly, Etheridge, J. T. Hall, de Tromelin, and others; and on the 19th of July, 1879, Mr. Vicary writes me, "I have never seen Silurian and Devonian forms in the same stone."

In 1869 I stated that the quartzites and sandstones, whether Devonian or Silurian, differed so little, if at all, in composition and colour that unless the pebbles contained fossils it was impossible to separate those belonging to the two periods. While writing my paper in 1869 for the Exeter Meeting of the British Association, I found it out of my power to class with certainty several new species occurring in the pebbles when they were unaccompanied by any known species. I am still under the same uncertainty with respect to some few of them; but with regard to others, known species having been found along with one or more of them in the same pebble, it has been possible to assign to them their correct geological position. In that paper I described and figured thirty-five species of Brachiopoda, and only a very few more have been discovered since that period.

Mr. Salter, with whom I often conversed upon the subject, was always under the impression that the pebbles had been drifted from Normandy and Brittany, or from between those regions and South Devonshire.

After the reading of my paper to the Geological Society of London in 1869, Mr. Etheridge observed that he assigned the rocks from which the pebbles had been derived to the Hangman (Devonian) group of North Devon; and that at Ansley Cove Mr. Tawney had lately found a series of the same class of fossils in a matrix exactly similar to that of the pebbles. Again, in 1870, in the discussion that followed the reading of Mr. A. E. Ussher's paper, Mr. Etheridge said that he had been able to ascertain, from specimens in the Penzance Museum, that the Budleigh pebbles (the Lower-Silurian ones) came from Gorran Haven, on the south coast of Cornwall, and that *Orthis redux* (our *O. Budleighensis*, not *O. redux* of Barrande) was common among the specimens at Penzance. Mr. Whitaker on the same occasion observed that he himself, on lithological grounds, suggested Gorran Haven as the source of the Budleigh-Salterton pebbles.

It was quite natural that British geologists should desire to find on British soil the rocks, *in situ*, from whence the "pebbles" had been derived; and that they thus should also prefer to find a visible source, rather than search for it either in Normandy or in the mid-Channel between France and Devonshire.

We will, for convenience, discuss each hypothesis separately:

1. The supposed British Devonian source;

2. The assumed British Silurian source;
3. The supposed Normandy and Brittany source;
4. The assumed mid-Channel source;

and afterwards sum up the conclusions that may be derived from any facts that may have been brought to bear on the subject.

1. The supposed British Devonian Source of Derivation.

Although we have in Devonshire and in Cornwall Devonian Sandstones, in none of the rocks of those counties have I found the assemblage of species that occur in the pebbles; and, if we except *Sp. Verneuilii* and three or four more, the greater bulk of the species are not known to occur in British Devonian rocks. The Hangman Grits in particular contain, according to Mr. R. H. Valpy,[1] no Brachiopoda and, independent of their fossils, they have a very marked lithological character or facies quite different from that of the pebbles. At p. 20 of the new edition of Mr. Valpy's 'Notes on the Geology of Ilfracombe and its Neighbourhood' it is stated in a foot-note: "Writing now, in 1880, there seems no doubt that the *Stringocephalus* bed is above the Hangman Grits;" and in a letter, dated 20th August, 1880, Mr. Valpy writes me: "The *Stringocephalus* bed seems above those grits, and seems, indeed, the basement of the Ilfracombe group, if that group is to be severed from the Hangman beds; this, however, seems *sub judice*. Owing to the very hard and impracticable nature of the matrix, it is very difficult to obtain an example of the fossil. I was therefore led into error when I stated in my paper in the 'Geological Magazine' for August, 1880, that the Hangman Grits contain very few Brachiopoda besides *Stringocephalus Burtini*, but was correct when I said that that species has not been hitherto found in the Budleigh-Salterton pebbles." In a letter I received from Mr. Pengelly on the 13th of September, 1879, that distinguished Devonshire geologist says: "I never thought the hypothesis of the Hangman as a source of the pebbles was worth a second thought." Major A. Wyatt-Edgell writes me on the 26th of August, 1879: "From the Hangman of North Devon I have never seen anything I could mistake for a Budleigh-Salterton fossil." The same view is expressed to me by Mr. Townshend Hall, who has made so close a study of North-Devon rocks and fossils.

Having communicated on the subject with Mr. A. E. Ussher, he writes me on the 30th November, 1879: "Any one knowing anything about the relations of the Trias of Devon must be aware that such a derivation from North Devon is quite impossible. If the Hangman beds are to be found, or their representatives, in South Devon and

[1] 'Notes on the Geology of Ilfracombe,' &c. At p. 23 of this Guide Mr. Valpy quotes from the Hangman Grits the following fossils:—*Bellerophon, Cucullæa, Euomphalus, Macrocheilus, Myalina, Mytilus, Natica, Pleurotomaria, Sanguinolaria, Solen*, with two Corals, and a *Fenestella*.

Cornwall they must be identified first, and cooked up for pebble purposes afterwards. As far as a derivation from the Hangman Grits zone, in which, by-the-bye, fossils are extremely rare, it is not even theoretically admissible imprimis. The Budleigh pebbles proper are replaced by local materials somewhere about the latitude of Burlescombe; and the bed at a few miles further passes into hard conglomerate, local limestone, and grit pebbles. This hard conglomerate with local fragments is the sole representative of the pebble division in the only part of North Devon and West Somerset area where we can say the Hangman beds were exposed to Triassic waters, *i.e.* the Bridgewater and Willeton areas; yet it is very uncertain, even in these, whether Hangman beds were exposed so early as the commencement of the 'Keuper,' the age I assign to the Budleigh-Salterton beds. The general character of the Hangman Rocks is unlike that of the fossiliferous pebbles of Budleigh, but I dare say that many of the numerous unfossiferous varieties of pebbles in the bed might be paired with specimens from Hangman and Foreland Rocks, which would be no proof of derivation from them; and, indeed, I find it not the least arduous of my duties about here to draw the distinctions between grits of different ages, which although nature has broadly distinguished in general characters, it seems at times as though she had forgotten to cleanse the old tints from the brush or change the stippling of her textures."

In another letter Mr. Ussher enters into long details to show that it was not possible, or at all probable, that the Devonian element of the Budleigh-Salterton pebbles could have come from rocks situated in the Foreland coast.

With respect to the supposed derivation from Smuggler's Cove, Torquay, Mr. Tawney, in a paper published in vol. vii of the 'Geological Magazine,' states that that assumed source of derivation must be given up.

With regard to the other Devonian rocks *in sitú* in Devonshire and Cornwall, there exists no evidence that I can see as to their having contributed to the mass of Budleigh Salterton pebbles. It is therefore evident that one must seek out of England for rocks that may have furnished the element of the Budleigh pebbles. In the sequel we will again revert to this subject when treating of the Normandy and Brittany sources.

2. The assumed British Silurian Source of Derivation.

The Lower-Silurian Rocks of Cornwall have been described by Sir H. de la Beche,[1] the Rev. A. Sedgwick,[2] and others,[3] to whose works the reader is referred. Mr. Collins states in his memoir already quoted that the Lower-Silurian Rocks of Cornwall

[1] 1839. Report on the Geology of Cornwall, Devon, and West Somerset.

[2] 1852. On the Slate Rocks of Devon and Cornwall, with List of Fossils, by Prof. M'Coy—Quart. Journ. Geol. Soc., vol. viii, Feb., 1852.

[3] 1841. *Phillips.* Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset.

consist largely of slates and shales, with some very thick conglomerates, some quartzites, and a few beds of thin limestone, that the bands of quartzite and limestone have yielded fossils (chiefly Orthidæ), which are pronounced to be of Bala or Caradoc age by Davidson and others, that they extend over nearly 200 square miles, and reach southwards beyond Halford River and westwards to Marazion.

It is to Mr. C. W. Peach's energetic and persevering exertions and researches that we owe the discovery of the Silurian fossils at Gorran Haven, Caerhayes, Verian Bay, and some other places. He says that although the quartz-rock of Cornwall occurs in various places along the coast from St. Austel Bay to Nasehend, near the Lizard, a distance of at least forty miles, it is nowhere plentiful; although thick, it is bedded; and crops out only occasionally: it is thus rather rare, and the fossils much more so, though, when found, several occur together.

Sir R. Murchison places the Cornish Lower-Silurian Rocks in his Caradoc division, from their fossil contents. I have, however, failed to find from the Dodman district reddish quartzites similar in colour to that which prevails at May, in Normandy, although I have no doubt as to their being of the same geological age.

As South Cornwall has been pointed out by Mr. Peach, Mr. R. Etheridge, and some others, as the probable source of derivation of at least a portion of the Budleigh-Salterton pebbles, I considered it necessary, as well as desirable, to make a minute and searching examination of the rocks and fossils that occur in that portion of England, the necessary material having been liberally lent to me out of the Museums of Penzance and Truro, the Museum of Practical Geology, London, the Woodwardian Museum, Cambridge, and the Edinburgh Geological Society's Museum, and by Mr. Peach, Mr. Collins, and Major Wyatt-Edgell.[1] I may therefore commence by observing that only a very small portion of the rocks in question are fossiliferous. The fossils occurring here and there are difficult to obtain, and are generally in a bad or indifferent state of preservation, so that out of the large number of fragmentary specimens procured, a very small proportion retained their natural shape. None, with the exception of a few Trilobites, had been previously classified or illustrated.

1852. *M'Coy.* Systematic Description of British Palæozoic Fossils in the University of Cambridge.

1867. *Sir R. Murchison.* Siluria, 4th ed., chap. viii, p. 145.

1878. *J. H. Collins.* Preliminary Notes on the Stratigraphs of West Cornwall—Trans. of the Royal Geol. Soc. of Cornwall, 1878.

1880. *J. H. Collins.* On the Age of Central and West Cornwall—Quart. Journ. Geol. Soc., 1880.

[1] I wish here to express my thanks to Prof. W. W. Smyth, F.R.S., President of the Royal Geological Society of Cornwall, and Inspector of the Crown Mines of England, and to the Council of the same Society, and to the Penzance Museum Committee, as well as to its Curator, Dr. C. Le Neve Foster, and Mr. W. Ambrose Taylor; also to the President and Council of the Royal Institute of Truro, and to Mr. J. H. Collins for the loan of all the specimens I required from the Penzance and Truro Museums; to Mr. Etheridge, F.R.S., President of the Geol. Soc.; to Prof. T. McKenny Hughes; to the Council of the Geol. Soc. of Edinburgh; to Mr. Peach, Major Wyatt-Edgell, Mr. Linford, and others.

Prof. Sedgwick [1] gives a list of the species which M'Coy thought he had been able to identify, viz.:

From Great Peraver, north of Gorran Haven.

Orthis elegantula, *Dalman.* Said to be rare. I have not seen even a fragment of the shell among the specimens preserved as having been examined by M'Coy.

— parva, *Pander.* Said by M'Coy to be very abundant. I have no doubt that the specimens he referred to Pander's species were such as were afterwards erroneously identified with Barrande's *O. redux*, and to which we have given the name of *O. Budleighensis.*

— calligramma (?), *Dal.* Is abundant where it is found.

— turgida, *M'Coy.* Said by M'Coy to be very abundant; I have not seen it. It is doubtless a mistaken identification.

— flabellulum, *Sow.* Although stated by M'Coy to be very abundant, I have not noticed a single fragment of the species.

Calymene brevicapitata, *Portlock.*

— parvifrons (?), *Salter.*

Homalonotus bisulcatus, *Salter.*

From the Quartzite of the Great Carn.

Orthis testudinaria, *Dal.* Said to be abundant. It is doubtless the shell we have named *O. Budleighensis.*

— retrorsistria, *M'Coy.* Said to be abundant. I have seen the specimens referred to, in the Cambridge Museum; they belong to *O. Budleighensis.*

From near Porth Caerhays.

Orthis grandis (?), *Sow.* I believe this identification to be correct; it is the *Strophomena grandis*, Sow. sp.

Cycloceras, sp.

Prof. Sedgwick says: "All the above species (with the locality of each specimen carefully recorded) are placed in the Museum at Penzance. . . . Specific names were not affixed to many of the specimens; and for the previous list I rest entirely on the authority of Prof. M'Coy."

After a very careful examination of all the specimens upon which Prof. M'Coy founded his list, as now preserved in the Penzance and Truro Museums, I found only three, viz. *Orthis calligramma, Orthis testudinaria* or *Budleighensis*, and *Strophomena grandis*, that were correct.

The species are very few in number. I have recognised the following five only; and

[1] 'Quart. Journ. Geol. Soc.,' vol. viii, p. 13.

of these I have given a series of figures in Sup., Pl. XLII, drawn expressly to accompany this Monograph, in order to facilitate comparisons with those species that have been found in the Budleigh-Salterton pebbles.

1. Strophomena grandis, *Sow.* Sup., Pl. XLII, figs. 1—6. Imperfect impressions and internal casts of this species occur in light-grey quartzite at the Carn of Gorran and Caerhayes. Penzance and Truro Museums.
2. Orthis calligramma, var. *Dal.* Figs. 7—10. Distorted internal casts and impressions of the exterior occur rather abundantly in a dark-grey or greenish ferruginous rock, at the Carn of Gorran Haven, Great Peraver, Caerhayes, and St. Austell. It does not appear to occur in the light-grey quartzite. Good examples may be seen in the Museums to which I have already referred to.
3. — scotica, *Dav.* Figs. 11, 12. I believe some impressions of separate dorsal valves, occurring in the same rock along with *O. calligramma*, may probably belong to this species. Gorran Haven. Penzance Museum.
4. — Berthosi, var. cornubiensis, *Tromelin.* MS. Figs. 14, 15. An internal cast of a single dorsal valve, and some imperfect impressions of the exterior, have been collected. Fig. 14 *a* shows the interior of the dorsal valve taken in gutta-percha from the internal cast (fig. 14). I believe this must be the fossil Prof. M'Coy has mistaken for his *Orthis turgida.* M. de Tromelin believes it to be a variety of *Orthis Berthosi,* Rouault. It occurs in a ferruginous sandstone at Caerhayes. The figured specimen belongs to the Truro Museum.
5. — Budleighensis, *Dav.* Figs. 16—25. I need not here anticipate what I have said further on with respect to this species in my description of the shell as found at Budleigh-Salterton. No doubt it is the fossil referred to *Orthis testudinaria,* Dalman, by Prof. M'Coy. Fig. 26 of my plate is taken from one of Dalman's types in the Stockholm Museum, and given here for the sake of comparison. When one compares it with such specimens as fig. 21, and others from the Cornish light-grey quartzite, one cannot help feeling that Prof. M'Coy had some grounds for his identification.

Orthis Budleighensis (better known by the mistaken name of *O. redux,* Barrande) occurs sparingly in light-grey quartzites at the Carn of Gorran Haven, at Caerhayes, and Gorran's Bay, from which localities specimens may be seen in the different Museums already named. Examples of the same species have been also discovered by Mr. Collins in a continuation of the same band of quartzite south of the Helford river.

It is very evident from the original tablet in the Cambridge Woodwardian Museum

that Prof. M'Coy identified some specimens of *O. Budleighensis* with *Orthis retrorsistria*, to which, however, they do not belong, although some small flat dorsal valves from the Middle Bala Slates of Cerigdrudion and other places, in the Woodwardian Museum, very closely resemble similarly flattened valves of *Orthis Budleighensis* that occur in the light-grey quartzite of Cornwall. *O. Budleighensis* never, however, attains the dimensions of full-grown *O. retrorsistria*. If, therefore, my identifications are correct (and for these I have given figures), the light-grey quartzite of Cornwall would represent the "Grès de May" of Normandy with its characteristic *Orthis Budleighensis*. It will also be remarked that all the Brachiopoda found in the Lower-Silurian Rocks of Cornwall are of Bala or Caradoc age, and that we have not yet discovered in Cornwall beds of quartzite representing the "Grès Armoricain," nor any of its characteristic species, such as *Lingula Lesueuri*, *L. Hawkei*, *L. Salteri*, and *Dinobolus Brimonti*, which are all found at Budleigh-Salterton in the quartzite pebbles.

Only two species of the "étage du Grès de May" that occur in Cornwall, *Orthis Budleighensis* and *Orthis Berthosi*, var., are found in pebbles at Budleigh-Salterton; therefore, even if some of the pebbles in the last-named locality were derived from Cornwall, we would have to seek out of Great Britain for rocks, *in sitû*, whence all the other species must have been derived.

I am ready to admit, with Messrs. Peach and Etheridge, that some pebbles found at Budleigh-Salterton are similar to the quartzites of Cornwall, and contain one or two of the same species; but it seems strange that, if the quartzite pebbles came from there, we do not find along with them pebbles of the dark-grey or greenish ferruginous rock which in Cornwall contains *Orthis calligramma*, *O. scotica*, and *Strophomena grandis*.

At one time Mr. W. Linford was in favour of a southern derivation of the Budleigh pebbles, but he now seems very doubtful that such was the case, and thinks a south-west derivation more probable. It has also been suggested that the red quartzites of May, in Normandy, could not be the same as the grey quartzites of Cornwall, but even in Normandy the quartzites of the "Grès de May" vary in colour at St. Germain-sur-Ille, Jurques, Campandré, Mont Robert, &c., some being reddish, others grey, yellowish, or even nearly white. M. de Tromelin seems to think, likewise, that it is not from Cornwall that the Lower-Silurian pebbles were derived, but considers them of French origin.

It will also have to be ascertained if any portion of Cornwall was submerged in as early Triassic times as those during which the pebble-bed was deposited; but these and allied geological questions I must leave for other investigations. I have simply dealt with what appeared to me to be the facts of the case, as far as I have been able to make them out, and the volumes of the Palæontographical Society ought not to be occupied with lengthened discussions on geological questions. I have, however, felt obliged to enter briefly upon certain considerations, as they are connected with the age of the pebbles and the species of fossils they contain.

3. The supposed Normandy and Brittany Source of Derivation.

A great deal has been published on the Palæozoic rocks of Normandy, Brittany, and the Department of the Manche, by M. Marie Rouault, M. Bonissent, M. Morière, and M. Ch. Barrois, and especially by MM. de Tromelin and Lebesconte.[1] We need not, however, refer to any of the Silurian or Devonian Rocks of Normandy and Brittany that are not sandstones or quartzites similar in composition to those that occur at Budleigh-Salterton.

1st. In 1850, M. Marie Rouault discovered in Brittany a new formation in the Lower Silurian, namely a sandstone which he stated to be generally white, greyish-blue, or yellow, and which graduates from soft sandstone into quartzites of various degrees of compactness. It contains, besides other fossils, *Lingula Lesueuri*, *L. Brismonti*, and *Lingula Hawkei*, Rouault. It represents the lower portion of the Lower Silurian, or, according to M. de Tromelin, the base of the Llandeilo or even the "Stiper Stones." It occurs at Guichen, Lion, Pontréan, Plechatel, Chateaubriand, Laillé in Brittany, also at Bagnoles (Orne) and elsewhere.

[1] 1848. *Marie Rouault.* Catalogue des Fossiles du Terrain Paléozoique des Environs de Rennes, Bretagne.—Bull. Soc. Géol. de France, 2nd ser., vol. iv, p. 322, 1846.

1848. *Marie Rouault.* Sur la Composition du Test des Trilobites, &c.—Bull. Soc. Géol. de France, 2nd ser., vol. vi, p. 67, 1848.

1850. *Marie Rouault.* Note préliminaire sur les Fossiles de l'Étage du Grès Armoricain—Bull. Soc. Géol. de France, 2nd ser., vol. vii, p. 728, 1850.

1851. *Marie Rouault.* Sur les Terrains Paléozoiques des environs de Rennes—Bull. Soc. Géol. de France, 2nd ser, vol. viii, p. 358, 1851.

1855. *Marie Rouault.* Notice sur quelques espèces de Fossiles du Terrain Devonien du Nord du Dépt. de la Manche—Bull. Soc. Géol. de France, 2nd ser., vol. xii, 1855.

1863. *Bonissent.* Essai géologique sur le Dépt. de la Manche, 4me époque Terrain Devonien, 3me époque Silurien—1863.

1875. *De Tromelin et Lebesconte.* Essai d'un Catalogue raisonné des Fossiles du Dépt. du Maine, &c.—Assoc. Franç., pour l'avancem. de la Science; Congrès de Nantes.

1876. *De Tromelin et Lebesconte.* Observations sur les Terrains primaires du Nord du Dépt. de l'Ille-et-Vilaine et de quelques autres parties du massif Breton—Bull. Soc. Géol. de France, 3rd ser., vol. iv, p. 583.

1877. *De Tromelin.* Etudes de la Faune du Grès Silurien de May—Bull. de la Soc. Linn. de Normandie, 3d ser., vol. i, p. 5, 1879.

1877. *De Tromelin.* Etudes des Faunes Paléozoiques de la Basse Normandie, particulièrement dans les Dépt. de l'Orne et du Calvados; Congrès du Havre, 1877.

1877. *Ch. Barrois.* Note sur le Terrain Devonien de la Rade de Breste—Ann. Soc. Géol. du Nord, t. iv, p. 59, 1877.

1877. *d'Œhlert.* Sur les Fossiles Devoniens du Dépt. de la Mayenne—Bull. Soc. Géol. de France, 3d ser., vol. v, p. 378, 1877.

1878. *J. Morière.* Note sur le Grès de Bagnoles—Bull. Soc. Géol. de Normandie, 3d, ser., vol, ii, 1878.

No other species of Brachiopoda besides *Lingula Salteri* and indeterminable fragments of internal casts of *Orthis* and *Athyris ?* have been noticed from the "Grès Armoricain." This sandstone or quartzite entirely agrees in mineral composition, aspect, colour, and fossil contents, with certain pebbles (see p. 323) of Budleigh-Salterton; and if specimens were mixed up together they could not be distinguished. As far as I am aware, "Armoricain" rocks of that epoch, with their characteristic fossil remains, do not occur *in sitû* in Great Britain; so that the Budleigh-Salterton pebbles of that age must have been drifted from rocks, *in sitû*, somewhere out of England, and the French localities are the only ones where we at present know quartzite rocks of that age to occur.

2nd. Higher up in the series of Lower-Silurian rocks, in France, we come upon thick beds of sandstones and quartzites of Caradoc age. These are largely developed in Normandy, in the Department of the Manche, in Brittany and elsewhere; and, as already stated, these are best known in France by the name of the "Étage du Grès de May." In Normandy, these rocks were first noticed by M. Hérault in the 'Annales des Mines' for the year 1824, also by M. de Caumont,[1] Prof. Deslongchamps,[2] and especially by M. de Tromelin in 1877.

The rock or quartzite composing the "Grès de May" varies considerably in composition and colour in different localities. At May, in Normandy, it is a hard, compact, reddish quartzite, extensively quarried for excellent road-material, but at Jurques, Campandré, Mount Robert, and other places in Normandy, it is either white, light-grey, or yellow. The grey kind of Jurques also very nearly resembles the light-grey quartzite met with, *in sitû*, in South Cornwall; and certain pebbles of similar rock at Budleigh-Salterton present all the variations in mineral composition, from soft sandstone to compact hard quartzites, which we find in Normandy. The prevailing Brachiopod at May is *O. Budleighensis;* and so likewise in these particular pebbles at Budleigh-Salterton. At May, M. de Tromelin found likewise, but very rarely, *Orthis Berthosi*, var. *erratica*, and *Lingula Morierei*, species that occur likewise in these Budleigh-Salterton pebbles. The same sandstone, with *O. Budleighensis*, was also found by Mr. Bonissent in various places in the Department of the Manche.

From any of the places above named, the Budleigh-Salterton pebbles of that age might have been derived, so similar are the rocks and fossils that occur in both localities; but it is more probable, and indeed I might say certain, that the rock furnishing the pebbles of the age of the "Grès de May" occurred much nearer to our island.

In Brittany the rocks belonging to the period of the Grès de May differ somewhat from those of Normandy. For instance, at St. Germain-sur-l'Ille (Ille-et-Vilaine) the

[1] "Mémoires Géologiques sur quelques terrains de la Normandie occidentale" ('Mém. de la Soc. Linnéenne du Calvados,' 1825); also "Essai sur la Topographie géognostique du Départment du Calvados," 1828.

[2] "Mémoire sur les corps organisés fossiles du grès intermediane du Calvados" ('Mém. de la Soc. Linn. du Calvados,' 1828).

rock in question is a tough coarse quartzite, white, light-grey, or light-yellow, and abounding in internal casts and impressions of the exterior of *Orthis Berthoisi*, var. *erratica*, but these are almost always more or less out of shape, and somewhat compressed. At Budleigh-Salterton we do not, as far as I am aware, meet with pebbles of a similar nature; on the contrary, that fossil has generally preserved its natural shape. I would not, therefore, point to that rock at St. Germain-sur-Ille as a possible source of derivation for the Budleigh pebbles. It is in pebbles referred to the age of the "Grès de May" that we find at Budleigh-Salterton the larger number of Lower-Silurian Brachiopoda; but for all details regarding Lower-Silurian sandstones and quartzites and their fossils, as well as those from the "Grès Devonien" or Lower-Devonian sandstones of Normandy and Brittany, I must again refer the reader to the able memoirs of M. Gaston de Tromelin and M. Lebesconte.

Above the Silurian formation already described we find the lower divisions of the "Étage Devonien à *Orthis Monnieri*" of Tromelin; and here we also find large deposits of sandstones of different degrees of compactness, as well as of colour, whitish-grey and yellow, often ferruginous, being the prevailing colours; and these agree completely with the pebbles assigned to that period that occur at Budleigh-Salterton. Many of the same fossils, and in the same condition of internal casts and external impressions, occur in the pebble of one, and the rock of the other country. *Orthis Monnieri*, Rouault, = *O. Vicaryi*, Dav., being thus found both in Brittany and at Budleigh-Salterton, rocks similar to these above mentioned must have furnished the great mass of Devonian pebbles accumulated on the South-Devon coast, and for many miles inland.

I need not enlarge further upon this possible source of derivation, as another may perhaps have existed at one time and nearer our shores.

4. The assumed Mid-Channel Source of Derivation.

It has been clearly shown that there exists on the other side of the Channel sandstones and quartzites *in situ*, which entirely agree in colour, composition, and organic contents with that of the Budleigh-Salterton pebbles. It has been suggested by several geologists that an extension of the same rocks may have existed in some parts of the Channel area between the coast of France and that of South Devon, and that from thence the pebbles now accumulated in Devonshire may have been derived by denudation. This view of the case has been entertained and expressed by Prof. Ramsay and others; and it certainly bears with it some degree of possibility, and even probability, although it cannot be demonstrated by any direct evidence.

Mr. Ussher thinks that the stratigraphical evidence would bear also in that direction; and in a letter he wrote to me on the 30th of August, 1879, he says:—"As to the Gorran Haven, or rather to an extension (formerly) of Gorran Rocks Channelwards, if your investigations lead you to that source, there is nothing against it, inasmuch as the

presence of marginal Trias sediments (Bunter) here and there fringing the coasts, as at Slapton, Thurlstone, and Mount Edgecombe, seems to indicate a rough coincidence between the present cliff-line and that of the early Triassic sea. But I think on stratigraphical evidence the Channel bed focusses most of the facts, although we cannot get at it, and therefore naturally prefer a visible source."

In a paper read to the Devonshire Association at Ilfracombe in July, 1878, Mr. Pengelly says, when speaking of the Budleigh pebbles, that their rounded polished state favours the idea that they had travelled long, and probably from far, and adds:— "It has been suggested, and perhaps with great probability, that their source was none of the foregoing localities [Normandy or the Dodman district], but a reef lying between them, perhaps a once continuous barrier crossing the Channel and connecting the whole. In short, by common consent, the pebbles came from somewhere about the south-west of the Budleigh-Salterton pebble-bed. There was an open sea between the Atlantic and what is now South-east Devonshire, and the transportation of material was in that direction in Triassic times, as it was in the raised-beach area and is at present."

Mr. Townshend Hall also observes, in an article in White's 'History of Devonshire,' 1878, that "The presence of Budleigh-Salterton pebbles may be accounted for, without the necessity of the conclusion that they must have travelled from Normandy, on the supposition that in pre-Triassic times reefs of Silurian and Devonian rocks extended southwards towards the coast of France over an area now occupied by the Channel, and that the destruction of these afforded for a limited time the material from which the pebbles had been derived." In this view I also concur.

Quartzite pebbles, indentical in colour and mineral composition with those that occur at Budleigh-Salterton, and containing some of the same fossils, have been found in the Drift scattered over a considerable surface of England, as far as Birmingham. Thus, for example, the Rev. P. B. Brodie many years ago found *Orthis Budleighensis* and *Lingula Lesueuri* in quartzite pebbles in the Drift of Warwickshire. Mr. Harrison picked up a similar pebble with *O. Budleighensis* in the Chalky Boulder-clay of Counterthorp, at about five miles south of Leicester. Mr. Jennings records similar pebbles with same fossil from Nottingham. Mr. Spencer G. Perceval found quartzite pebbles identical in appearance with those that occur at Budleigh-Salterton with *O. Budleighensis*, and others with *Spirifer Verneuilii*, in the Drift at Sparbrook and Ladypool Lane, near Moseley, Birmingham; also at Hartborne, a locality south-west of Birmingham. These pebbles were presented by Mr. Perceval to the Museum of Practical Geology in London, where they can be seen.

In the Woodwardian Museum, Cambridge, may likewise be seen a quartzite pebble with *Lingula Lesueuri*, found by Mr. Houghton in the Drift of Ladypool Lane, near Birmingham. A quartzite pebble with *Discina Vicaryi* was also picked up by Mr. Vicary on the Chesil Bank, all denoting how widely spread are similar pebbles to those accumulated at Budleigh-Salterton and its neighbourhood.

Many speculative views have been brought forward with respect to the sources of derivation of those Midland-Counties Drift pebbles that contain *Orthis Budleighensis* and *Lingula Lesueuri;* but none have met the exigencies of the case. According to Professor Hull's theory, the Midland-Counties pebbles were probably derived from the Old Red conglomerates, no rock *in sitú* having been discovered from which they can be traced. The Rev. P. B. Brodie has also, in the 'Quarterly Journal of the Geological Society,' touched upon the question; and quite recently, in the 'Geological Magazine,' new series, vol. vii, p. 404, 1880, Prof. T. G. Bonney has published an interesting paper on "Pebbles in the Bunter Beds of Staffordshire." Referring to these pebbles he says that two kinds of quartzite pebbles are found in the Bunter; one kind he believes to have been largely derived from the rocks in the north-west of Scotland; the other set he states to be more granular and altogether less compact in texture, resembling more the quartzites of Budleigh-Salterton, the Lickey, and Hartshill; to this rock, he states, belong, so far as he has seen them, the pebbles collected by Mr. Perceval and Mr. Jennings. I must, however, leave this matter for further consideration, and proceed without delay to the description of the species of Brachiopoda that occur in the Budleigh-Salterton pebbles.

Conclusion.—I have endeavoured, briefly and fairly, to express the views entertained by geologists with respect to the four sources of derivation, and it seems to me that the Channel hypothesis is the one that offers the greatest degree of probability, although it is not possible to put the matter to the test. It has also been shown that rocks *in sitú*, agreeing with that of the pebbles, and with the same fossils, occur abundantly in Normandy, Brittany, and the Department of the Manche; also that no Devonian nor Silurian Rocks in England have shown a similar assemblage of species as those that occur in the pebbles,—that the pebbles of the age of the "Grès Armoricain" could not have been derived from Silurian Rocks of that period in England,—and that only one or two of the Caradoc species of Brachiopoda found in the pebbles could have been obtained from Cornish quartzites.

Description of the Brachiopoda that occur in the Budleigh-Salterton Pebbles.

I have felt it desirable to notice and figure every species that has been collected from this very remarkable locality. Unfortunately, of a few the material has been incomplete and scanty, there being imperfect internal casts and external impressions only. Hence it was not possible in some instances to hazard a specific identification; but of the larger number of species it has been possible, by the means of white gutta-percha, to reproduce both the external and internal surface of both valves, and to arrive at a satisfactory specific identification.

I have divided these species, generally correctly I believe, into the two systems; but it is very possible that one or more of those classed as Devonian may eventually turn out to be of Silurian age. This in all probability will be hereafter made certain by the discovery in the same pebble of two or more species of well ascertained age. We here notice all that we know to draw attention generally to the subject, and specially to interest those geologists who may be collecting in the locality.

As already stated, it is sometimes very difficult to determine the real species to which some of the imperfectly preserved casts and moulds belong; and I frankly admit that I have, in certain cases, felt much uncertainty while giving to the fossil even a provisional specific name. I thought, however, that by doing so it might facilitate future research and reference; and no trouble has been spared in the endeavour to arrive as near as possible to the truth.

The following is as nearly correct a list as I have been able to make it of all the Devonian and Silurian species obtained from the Budleigh-Salterton pebbles:

Species from the Lower-Devonian Sandstone.

Terebratula sacculus, Martin.
? Athyris ? incerta, Dav.
„ *Budleighensis*, Dav.
„ *? erratica*, Dav.
Spirifera Verneuilii, Murchison.
„ *speciosa*, Schlotheim.
Spiriferina octoplicata, Sow.
Rhynchonella Winwoodiana, Dav.
„ sp. ? perhaps *R. inaurita*, Sandberger.
„ *inaurita*, Sandb.
Rhynchonella Thebaulti, Rouault.
„ *elliptica*, Schnur ?
? „ *Vicaryi*, Dav.
? „ *Valpyana*, Dav.
? „ sp ?
„ *ovalis*, Dav.
Orthis Hamoni, Rouault.
„ *Monnieri*, Rouault.
„ *Hipparionyx ?*
Strophomena Vicaryi, Dav.
„ *Rouaulti*, Dav.

Strophomena, Edgelliana, Dav.
„ *Budleighensis*, Dav.
„ *Etheridgei*, Dav.
„ sp.
„ sp.
„ *crenistria*, Phil.
Productus Vicaryi, Salter, sp.
Chonetes, sp.?
Crania transversa, Dav.
Discina Vicaryi, Dav.
„ *incerta*, Dav.
„ *? Edgelli*.

Lower-Silurian Species: Caradoc, or Grès de May.

Lingula Morierei, Tromelin.
Terebratula? sp.
Nucleospira Vicaryi, Dav.
Orthis Berthoisi, Rouault.
Orthis Berthoisi, var. *erratica*, Dav.
„ *pulvinata*, Salter.
„ *Budleighensis*, Dav.
„ *Valpyana*, Dav.

Lower-Silurian Species: base of Llandeilo, or Grès Armoricain of France.

Lingula Lesueuri, Rouault.
„ *? Hawkei*, Rouault.
Lingula Salteri, Dav.
Dinobolus Brimonti, Rouault, sp.

LOWER-DEVONIAN SPECIES.

All the fossils occur as either internal casts or impressions of the exterior; and are found in light-yellow, or reddish, or grey sandstones and quartzites, the rock agreeing entirely in aspect and composition with that of some sandstones and quartzites that occur *in sitú* in Normandy and Brittany on the other side of the Channel.

This Devonian sandstone agrees also with the Lower-Devonian Sandstone or "Grès Devonien inférieur à *Orthis Monnieri*," of French geologists, which may be seen at Gahard and other places.

1. Terebratula sacculus, *Martin*. Dav., Dev. Mon., Pl. I, figs. 1—8; Budl.-Salt. Sup., Pl. XXXVIII, figs. 1, 2, 3.

Among some specimens from Budleigh-Salterton, lent to me by Mr. W. Vicary and Mr. W. Linford, I at once recognised two small internal casts, and one impression of an exterior of Martin's species.

Internal casts of the following three species are provisionally classed in the genus *Athyris;* but from these one or two will probably have to be removed when more satisfactory and complete material shall have been obtained.

2. Athyris incerta, *Dav.* B. S. Sup., Pl. XXXVIII, fig 5.

Athyris incerta, *Dav.* Quart. J. Geol. Soc., vol. xxvi, p. 80, pl. iv, fig. 12, 1869.

Shell marginally more or less pentagonal, rather wider than long; dorsal valve moderately convex. Mesial fold broad, flattened, and longitudinally depressed along the middle. Ventral valve slightly more convex or deep than the opposite one, with a broad flattened sinus. Surface smooth.

Length 6, breadth 8 lines.

Of this species only one or two internal casts and an impression of the exterior have been found by Mr. Vicary. It is therefore difficult to arrive at a certain identification. Some indeterminable impressions of an *Orthis* and of *Tentaculites* have been found in same pebble. Its age, whether Devonian or Silurian, is uncertain.

3. Athyris Budleighensis, *Dav.* B. S. Sup., Pl. XXXVIII, fig. 6.

Athyris Budleighensis, *Dav.* Quart. Journ. G. S., vol. xxvi, p. 80, pl. iv, fig. 14, 1869.

Of this fossil the internal cast of the ventral valve has alone been discovered; it is almost circular, slightly wider than long, with two short slits in the beak, due to dental plates. It measures—length 9, width $9\frac{1}{2}$ lines; and is certainly a Devonian species, for it was found by Mr. Vicary in a sandstone pebble in company with *Spirifera Verneuilii* and *Rhynchonella inaurita.* Similar internal casts have also been found by M. Lebesconte in the Grès Devonien at Gahard in Brittany. I have given the cast in question a provisional name, but it is not perfect enough to warrant a specific identification.

4. Athyris? erratica, *Dav.* B. S. Sup., Pl. XXXVIII, fig. 4.

Athyris erratica, *Dav.* Quart. Journ. G. S., vol. xxvi, p. 80, pl. iv, fig. 13, 1869.

Of this fossil, a single small internal cast has been found by Mr. Vicary. It is therefore not possible to venture upon anything beyond a provisional generic and specific identification.

In shape the cast is elongate oval, with moderately convex valves. It measures—

Length 4, breadth 3, depth 2 lines.

On the cast of the dorsal valve there exists a long mesial longitudinal indented line, indicating the presence, in the interior of the valve, of a slightly raised narrow ridge,

extending to about two thirds of the length of the shell. There are, likewise, on the internal cast indications of radiating striæ. Nothing is known of the exterior. The beak in the ventral valve has two deep slits, indicating the presence of dental plates. The fossil may possibly belong to some species of *Rhynchonella*. It is, I believe, a Devonian fossil.

5. Spirifera Verneuilii, *Murch.* Dav., Dev., Mon., Pl. V, figs. 1—12; and Pl. VI, figs. 1—5. B. S. Sup., Pl. XXXVIII, figs. 9—14.

Spirifera Verneuilii, *Murch.* Bull. Soc. Géol. de France, vol. xi, p. 252, pl. ii, fig. 3, 6th April, 1840.
— disjuncta, *Sow.* Trans. Geol. Soc., 2nd ser., vol. v, pl. liii, fig. 8, and pl. liv, figs. 12, 13, 30th May, 1840.
— — *Dav.* Sil. Mon., p. 23, pl. v, figs. 1—12, and pl. vi, figs. 1—5, 1864.
— Verneuilii, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 78, pl. iv, figs. 19, 20, 1869.
For synonyms see Devonian Monograph, p. 23.

This species has been fully described at p. 23 of my Devonian Monograph under Sowerby's name *disjuncta;* later, in the 'Quarterly Journal of the Geol Soc.,' vol. xxvi, 1869, I gave back to the shell its name of *Verneuilii*, having discovered that it had a few weeks priority over that of Sowerby.

In a paper by M. Gosselet "De l'usage du droit de priorité et de son application au noms de quelques Spirifères" ('Annales de la Société Géologique du Nord,' vol. vii, 1880), that distinguished geologist enters into full particulars in order to prove the priority of Murchison's name *Verneuilii*, a fact that I had recognised and published many years previously.

Sp. Verneuilii is very variable in the shapes it assumes. According to its more or less transverse form, the expansion of its wings, and other small differences, it has received distinct specific names. It is one of the commonest fossils in the Budleigh-Salterton Devonian pebbles, where it occurs mostly in the condition of internal casts; but complete specimens showing the exterior under its various shapes are often found. In his description of this Spirifer in 1864, Mr. Salter, believing it to be Silurian, although recognising its resemblance to a Devonian form, describes and figures it under the names of *Spirifera antiquissima*, Salter, and *Sp. Davidis*, Rouault.

An internal cast in a sandstone pebble, similar in every respect to those that occur at Budleigh-Salterton, was picked up by Mr. Percival in a gravel-pit at Ladypool Lane, near Moseley, Birmingham, and may be seen in the Museum of Practical Geology, London.

6. Spirifera speciosa, *Schlotheim*, sp. Dav., Dev. Mon., Pl. VIII, figs. 6—8; and B. S. Sup., Pl. XXXVIII, figs. 15—18.

Spirifera macroptera, *Goldfuss*. Var. microptera, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 79, pl. iv, figs. 21, 22, 1869.

At p. 29 of my Devonian Monograph I described this species. It seems to have received several names. The Budleigh-Salterton specimens are not numerous, nor in a very complete state of preservation. It has been found once or twice in the same pebble with *Sp. Verneuilii* and *Rh. inaurita*. It occurs also in the Devonian Rocks of Brittany.

7. Spiriferina octoplicata, *Sow.* Dev. Mon., Pl. VI, figs. 11—15; and B. S. Sup., Pl. XXXVIII, figs. 7, 8.

Spiriferina octoplicata, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 79, pl. iv, fig. 23, 1869.

At p. 46 of my Devonian Monograph will be found a full description of this species. In external shape the Budleigh-Salterton specimens resemble the Carboniferous shell so named. It occurs sparingly on the pebbles along with *Orthis Monnieri* (= *O. Vicaryi*, Dav.). In Brittany it is found at Gahard, in a similar sandstone, in company with the same *Orthis* and *Rh. elliptica*.

8. Rhynchonella Winwoodiana, *Dav.* B. S. Sup., Pl. XXXVIII, fig. 19.

Of this species the internal cast of a dorsal valve was discovered by the Rev. H. W. Winwood in a quartzite pebble, in which were likewise present two internal casts of the ventral valve of *Orthis Hamoni*, Rouault.

In external shape the dorsal valve is almost circular, measures 9 lines in length by 10 in breadth, and is moderately convex; mesial fold wide and well defined. Surface ornamented by twelve or fourteen strong, wide, simple, angular ribs, of which the four largest occupy the fold, with a deep and wide longitudinal sulcus dividing the middle pair.

9. Rhynchonella, sp. (perhaps *R. inaurita*, Sandb. ?). B. S. Sup., Pl. XXXVIII, fig. 21.

In a fragment of a pebble in the Museum of Practical Geology we find incomplete portions or fragments of a *Rhynchonella*, the largest of the genus hitherto found at Budleigh-Salterton. It is not sufficiently complete to warrant our arriving at a specific identification. I have, however, thought it as well to figure the specimen for reference sake, and in the hope that more complete examples may be sought for and hereafter correctly identified.

The shell, when complete, measured about 11 lines in length by 12 in breadth. Fold in the dorsal valve wide and elevated, with sharp lateral slopes and a deep sinus. The valves are ornamented by about twenty-two simple angular ribs, of which four occupy the fold and three the sinus.

It bears some resemblance to *Rh. inaurita*, Sandberger, and may, perhaps, be referable to that species or to *R. Daleidensis*, F. Roemer.

10. Rhynchonella inaurita, *Sandb.* (?). Dav., B. S. Sup., Pl. XXXVIII, figs. 35, 35 *a*, *b*.

Rhynchonella inaurita, *Sandb.*? Die Brach. Rheinischen Schichtensystems in Nassau, p. 41, pl. xxxiii, fig. 5, 1855.

— — *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 80, pl. v, figs. 1—3, 1869.

Of this fossil internal casts alone have been found; they are marginally subtrigonal, wider than long, both valves convex; dorsal valve gibbous; mesial fold rising abruptly with greater or lesser breadth, and presenting in profile a regular convex curve. In the ventral valve the sinus is deep and broad, extending from the extremity of the beak to the front; beak incurved. Surface of each valve ornamented with from sixteen to twenty angular ribs, of which from three to six of the largest occupy the fold, while from two to five furrow the sinus. The ribs on the lateral portions of the valves are narrower.

Length 9, breadth 10, depth 6 lines.

It is with hesitation I have referred these internal casts to Sandberger's species; but, having submitted specimens of it to M. de Verneuil in 1863, he at once identified them with *R. inaurita*. It is a true Devonian fossil, and has been found in the same pebble along with *Sp. Verneuilii*, *Strept. crenistria*, *Prod. Vicaryi*, and *Crania transversa*.

11. Rhynchonella Thebaulti, *Rouault.* Dav., B. S. Sup., Pl. XXXVIII, figs. 26—29.

Terebratula Thebaulti, *Rouault.* Bull. Soc. Géol. de France, 2nd ser., vol. viii, p. 376, 1851.[1]

Rhynchonella, sp. *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 81, pl. v, figs. 5, 6, 1869.

In 1869 Mr. Vicary forwarded to me two internal casts (figs. 26, 27), but as no external impressions accompanied them I did not venture on a specific identification. Since then two more examples (figs. 28, 29) have been obtained by Major Wyatt-Edgell, and presented by him to the Museum of Practical Geology in London.

In shape these casts are somewhat subpentagonal, circular, or transversely oval, according to the number of ribs that ornament the mesial fold, but is usually a little wider than long. Dorsal valve convex, and deeper than the ventral one, with a well-marked and elevated mesial fold. Ventral valve with a deepish sinus; beak small, incurved. Surface of valves covered with about sixteen ribs, of which two, three, or four form the fold, one, two, or three the sinus. In those specimens with two ribs the lateral slopes are wide, a slight longitudinal slit in the umbo of the dorsal valve indicating the existence of a small ridge or septum in the interior of the valve.

Length 7, depth 8 lines.

This is certainly a Devonian fossil, as it occurs in the same pebble along with *Spirifera Verneuilii.* M. de Tromelin wrote me that it is the *T. Thebaulti* of Rouault, that he has seen the types, and that it occurs in the "Grès Devonien" at Gahard, in Brittany. I have never seen Rouault's specimens, but his description seems to agree with the shell from the Budleigh-Salterton pebbles.

12. Rhynchonella elliptica, *Schnur* (?). Dav., P. S. Sup., Pl. XXXVIII, figs. 22—25.

Rhynchonella elliptica, *Schnur, Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 81, pl. v, fig. 4, 1869.

Shell nearly circular, a little broader than long; dorsal rather more convex than the ventral valve, with a wide, slightly raised mesial fold, and similarly wide, moderately

[1] "*Terebratula Thebaulti,* Marie Rouault. Petite espèce de forme arrondie, épaisse, couverte de seize plis rayonnants dont deux appartiennent au sinus, et sur les deux valves qui sont très renflées; de tout ces plis, celui du milieu arrive du bord jusqu'à la charnière. Cette espèce se distingue du *T. bidenta,* Murch., de laquelle elle est très voisine, par sa taille plus petite, la plus grande largeur de son sinus, et le nombre plus grand de ses plis. Localité—Gahard."

deep sinus in the ventral valve; beak small and incurved. Surface of valves covered with a variable number of ribs, from sixteen to twenty-eight in each valve, of which from four to seven occupy the fold, two to five or six the sinus. In the interior of the dorsal valve there exists a short mesial septum, on each side of which are situated the muscular scars (fig. 23).

Length 8, depth 8½ lines.

Whether this *Rhynchonella* be referable or not to Schnur's species, it is one of the commonest in the Devonian pebbles of Budleigh-Salterton, and occurs in company with *Spirifera Verneuilii* and *Rh. inaurita*. This identification must, however, be considered as provisional. Similar internal casts are found in the Yellow Sandstone, "Grès Devonien," at Gahard, in Brittany.

13. Rhynchonella Vicaryi, *Dav.* B. S. Sup., Pl. XXXVIII, figs. 30, 31.

Rhynchonella Vicaryi, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, pl. v, figs. 7, 8, 1869.

Internal casts only have been found. Shell small, somewhat trigonal and compressed, longer than wide, broadest anteriorly, tapering at the beaks. Valves moderately convex; each valve ornamented with ten or eleven ribs, of which four to five compose the fold, three or four the sinus,

Length 5½, width 5 lines.

Of this small species I have seen several internal casts, but not sufficient to enable me to give a complete or satisfactory description of the shell. Mr. Vicary found it in the same pebble along with *Spirifera Verneuilii*.

14. Rhynchonella Valpyana, *Dav.* B. S. Sup., Pl. XXXVIII, figs. 33, 34.

Rhynchonella Valpyana, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, figs. 26, 27, 1869.

Shell small, longitudinally oval or ovate. Valves moderately convex. Surface ornamented with about thirteen simple ribs, of which the three largest form the mesial fold.

Length 5, width 4, depth 3 lines.

Two or three internal casts and an external impression have been found by Mr. Vicary. It is a Devonian fossil.

15. Rhynchonella, sp. Dav., B. S. Sup., Pl. XXXVIII, fig. 32.

Of this small species a single dorsal valve was found by the Rev. H. Winwood in a Budleigh-Salterton pebble. In shape it is marginally circular, as broad as long, with two short small ribs quite close to the front; the remainder of the valve is smooth.

Length 5 lines, breadth the same.

This *Rhynchonella* is quite distinct from all the other species of the genus we find in the Budleigh-Salterton pebbles; but with such scanty material it is not possible to attempt a specific identification.

16. Rhynchonella (?) ovalis, *Dav.* B. S. Sup., Pl. XXXVIII, figs. 36, 37.

Rhynchonella? ovalis, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 82, pl. iv, figs. 24, 25, 1869.

Shell small, as wide as long, or rather longer than wide. Ventral valve almost uniformly convex, with from eighteen to twenty simple ribs. Dorsal valve regularly convex, and ornamented like the other valve. Two specimens measured—

Length 3, breadth $2\frac{1}{2}$ lines.

„ 3, „ 3 „

Of this small species I have seen a few internal casts and external impressions, but not sufficiently numerous to enable me to give a complete description of the shell. It has been found in company with *Orthis Monnieri* and *Strophomena Budleighensis*, and is consequently of Devonian age.

17. Orthis Hamoni, *Rouault.* Dav., B. S. Sup., Pl. XXXVIII, fig. 20.

Orthis Hamoni, *Rouault.* Catalogue of the Fossils found in the Palæozoic Rocks of the neighbourhood of Rennes. Bull. Soc. Géol. de France, 2nd ser., vol. iv, p. 322, 1846.

— Michelini, var. *De Verneuil* (not of Leveille). Bull. Soc. Géol. de France, 2nd ser., vol. vii, p. 782, 1850.

— — *Bayle.* Explication de la Carte Géologique de France, tom. iv, Atlas, pl. xvii, figs. 10, 11, 1878.

In a large quartzite pebble, found at Budleigh Salterton by the Rev. H. Winwood, we find, in addition to the cast of *Rhynchonella Winwoodiana*, two internal casts of the ventral valve of an *Orthis*, which M. de Tromelin at once recognised as the *Orthis Hamoni* of Rouault. Rouault neither described nor figured his so-termed species. All he has published in reference to it is, " *Orthis Hamoni* (Rouault) voisin de *l'O. Michelini* et d'une espèce propre au Hamilton Groupe de l'état de New York—Loc. Gahard." M. de Tromelin having seen M. Rouault's type at Rennes alludes to it in his and M. Lebesconte's paper:—" Sur les terrains primaires du Nord du département de l'Ille-et-Vilaine et de quelques autres parties du massif Breton," and adds, p. 617, that the Grès à *Orthis Monnieri* is very well developed as far as beyond Caulnes (Côtes du Nord, &c.).

At M. de Tromelin's request Mr. Bayle gave two figures of the exterior and interior of the dorsal valve in the atlas, vol. iv, of the 'Explication de la carte Géologique de France.' From these last two figures, and the two internal casts obtained at Budleigh-Salterton, we may draw up the following description of the shell:

By the margin slightly transversely oval, broader than long. Ventral valve very moderately convex, and marked with numerous close, radiating, raised, striæ, crossed at intervals by a few concentric lines of growth. Area narrow. Ventral valve very slightly convex, with a mesial depression commencing at about the middle of the valve and widening as it nears the front. Surface covered with fine, thread-like, radiating striæ. In the interior of the dorsal valve the cardinal process is small, so likewise the diverging crural processes. The quadruple muscular impressions occupy an area of about one third of the breadth of the valve and nearly one third of its length, divided longitudinally by a narrow convex ridge. In the interior of the ventral valve the muscular area takes up half the length of the valve and about one third of its breadth. Prof. Bayle's two specimens measured—length 13, width 14, and length 10, breadth 11 lines; the English examples 6 lines in length by 8 in breadth. The French two specimens are from the Lower Devonian of Nehou (Manche) and Visé, Sarthe.

M. de Tromelin states in his paper that this species has been several times confounded with the *Orthis Michelini* of Leveille, a Carboniferous species, but from which it can be distinguished; also that it constitutes an excellent horizon whereby to determine the base of the Devonian system in the Departements of the Manche, La Sarthe, Ille-et-Vilaine, the Côtes du Nord, and the Finistère, and in many other places, which will be found enumerated in M. de Tromelin's paper. The same palæontologist adds that it approaches in character to *Orthis Eifelensis*.

18. Orthis Monnieri, *Rouault* (= *O. Vicaryi*, Dav.). B. S. Sup., Pl. XL, figs. 1—8.

Orthis Monnieri, *Rouault*. Bull. Soc. Géol. de France, 2nd ser., vol. viii, p. 376, 1851.
— Vicaryi, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, pl. v, figs. 20—22, 1869.

ORTHIS MONNIERI, de *Tromelin et Lebesconte*. Bull. Soc. Géol. de France, 3rd ser., vol. iv, p. 595, 1876.

Shell circular, or more often elongated, oval, slightly widest anteriorly; hinge-line straight, about half the breadth of the shell. Ventral valve moderately convex; beak slightly incurved; area narrow and small, divided in the middle by a rather wide fissure. Dorsal valve less convex than the ventral one, slightly depressed along the middle. Surface of both valves marked by numerous fine, radiating, thread-like striæ, which increase in number by the interpolation of shorter and smaller ones. In the interior of the ventral valve two large, deep, oval, muscular depressions occupy fully two-thirds of the length of the valve, and are divided in the middle by a narrow, angular, slightly projecting ridge. In the interior of the dorsal valve a small bilobed cardinal process is situated between the prominent, diverging, slightly curved, brachial processes; with a convex rounded ridge, extending from under the cardinal process to about half the length of the valve; on either side are situated rather large, elongated, adductor muscular impressions. Two specimens measured—

Length 7, width 7 lines.
„ 5, „ 4 „

Obs.—In 1869 I described this species by the name of *Orthis Vicaryi*, but since then M. de Tromelin has assured me that the shell so named was the same as the one named *Orthis Monnieri* by M. Rouault. It was, however, impossible for me or any one else to make out the shape and character of the shell from Rouault's so-termed description. He says: "Cette espèce, par le rapprochement très marqué des deux divisions qui naissent de l'impression interne du crochet de la valve dorsale [our ventral] et qui s'étendent sur la partie médiane de la coquille, se montre en général assez différente des exemplaires de l'espèce qui se trouve dans le Grès de May, et que l'on croit devoir rapporter à *Orthis reduæ*, Barr., et qui nous parait plutôt devoir se rapprocher de celle de Gahard. Celle-ci, à cause de son abondance, nous a permis de reconnaitre que ses caractères, d'abord differents se modifient, et nous possédons maintenant, provenant du Grès Coquillier de Gahard, tout les intermédiaires necessaires pour justifier ce rapprochement que nous faisons entre les èchantillons de ces deux localités."

I am quite ready to relinquish the name I gave to the fossil, although I can hardly admit that the fossil had been previously *described*, nor was any figure given of it by M. Rouault. I have, however, thanks to M. Lebesconte, been able to examine a number of good examples of the French fossil, and they agree in every particular with our Budleigh-Salterton specimens.

MM. de Tromelin and Lebesconte quote it likewise from the Devonian of the Cotentin and Rade de Brest. The same geologists state that the sandstone with *O. Monnieri* constitutes an excellent horizon by which to determine the lower part of the Devonian system in the Departement of the Manche, the Sarthe, Ille-et-Vilaine,

Côtes-du-Nord, and the Finistère; and in another paper, "Congrès du Havre," 1877, they add that in the Departement of the Manche the Devonian presents the great divisions recognised in Brittany, viz.:

Grauwacke with *Pleurodictyum problematicum.*

Calcaire à *Athyris undata* (Néhou, Beaubigny).

Grès à *Orthis Monnieri.*

In the 'Bulletin de la Soc. Géol. de France," 3rd ser., vol. iv, p. 615, 1876, M. de Tromelin states that the Devonian series in the Departement of Ille-et-Vilaine may be divided in the following manner:

3. Schistes de Montigné (Mayenne).
   Schistes et Grauwackes de la Lézaie, de la Coudraie, &c., à *Pleurodictyum problematicum.*
2. Calcaires à *Athyris undata* de Gahard, d'Izé, de la Baconnière, &c., frequemment mêlé de Schistes.
1. Grès à *Orthis Monnieri* de la Bodinaie près Pierrie (Loire-Inférieure), de Gahard, de Saint Aubin d'Aubigné, et Grès homologues.

Orthis Monnieri is not a very common species in the yellow-sandstone and quartzite pebbles at Budleigh-Salterton. Mr. Vicary has found it associated with *Spirif. Verneuilii* in the same pebbles. In the same rocks, along with it, we also find *Spiriferina octoplicata* and *Rhynchonella elliptica.*

Orthis Monnieri is mentioned by M. Bonissent as occurring in the Devonian of the Département de la Manche in his "Essai Géologique sur le Département de la Manche; Terrain Devonien;" 'Mémoires de la Soc. Impériale des Sciences Naturelles de Cherbourg,' 1863.

19. Orthis hipparionyx? *Vanuxem.* B. S. Sup., Pl. XXXIX, fig. 1.

A fragment of the internal cast of a large species of *Orthis,* somewhat resembling *Orthis hipparionyx,* occurs in a Budleigh-Salterton pebble in the Museum of Practical Geology. It is not sufficiently complete to warrant a certain specific identification. In shape it is semicircular, and slightly longer than wide, hinge-line shorter than the breadth of the shell, area narrow. In the cast the muscular area is large, pear-shaped, and divided longitudinally by a small ridge.

Specimens of *Orthis hipparionyx* resembling it occurs in the Oriskany Sandstone (Hall, 'Pal. New York,' vol. iii, pl. lxxxix, fig. 4). Well characterised specimens of Vanuxem's species are also found in the Devonian Sandstone at Looe, Cornwall; also in the "Grès Devonien" or étage à *Orthis Monnieri,* at Gahard, in Brittany. It bears, likewise, a resemblance to a specimen of *O. hipparionyx,* figured by Schnur in his work on the 'Eifel. Brachiopoden,' pl. xl, fig. 1 *a.*

20. Strophomena Vicaryi, *Dav.* B. S. Sup., Pl. XXXIX, fig. 8.

Strophomena Vicaryi, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, pl. vi, figs. 6, 7, 1869.

Shell transversely semicircular, regularly convex, with expanded angular extremities; hinge-line straight and long, with closely set slanting striæ; area narrow, fissure triangular; muscular impressions divided by a raised mesial ridge, external surface marked by numerous thread-like striæ, two or three finer ones being placed between each pair of the larger striæ; dorsal valve not known.

Length 8, breadth 11 lines.

Obs.—Of this species we are at present acquainted with one valve only; consequently a complete description of the shell cannot be drawn up. The shape of the muscular impressions in the ventral valve differs from those seen in *S. Edgelliana*. Mr. Salter also expressed the opinion that the two are specifically distinct. It has been found by Mr. Vicary in company with *St. Etheridgii* and *Rh. ovalis*, and is, no doubt, a Devonian species.

21. Strophomena Rouaulti, *Dav.* B. S. Sup., Pl. XXXIX, fig. 9.

Strophomena Rouaulti, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, pl. vi, figs. 8, 9, 1869.

Shell semicircular, slightly wider than long; hinge-line straight, a little less than the width of the shell; ventral valve very moderately convex, with a narrow area and open fissure; dorsal valve almost flat or very slightly concave. Exterior finely striated. In the interior of the ventral valve a small hinge-tooth is situated on each side of the base of the fissure, while the muscular scars form a large saucer-shaped depression, laterally margined by a slightly elevated ridge. In the interior of the dorsal valve a wide raised border surrounds the shell; hinge-area linear. The cardinal process is composed of two testaceous projections, under which are located two elongated, parallel muscular impressions, surrounded by a narrow elevated ridge, and separated along the middle by a rather wide interspace.

Length 10, width 11 lines.

Obs.—This species appears to be rare, only a few internal casts of the two valves having been seen by Mr. Vicary in the Budleigh-Salterton pebbles. As no other Brachiopod has been found associated with it in the same pebble, I cannot say positively whether the species is Devonian or Silurian, but I believe it belongs to the first-named formation. The shape of its muscular impressions seem to distinguish it from the other forms of the genus that occur in the locality.

22. Strophomena Edgelliana, *Dav.* B. S. Sup., Pl. XXXIX, figs. 5—7.

Strophomena Edgelliana, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 86, pl. vi, figs. 5—7, 1869.

Transversely semicircular, with expanded angular extremities; hinge-line as long as the greatest breadth of shell. Ventral valve slightly convex; area narrow, divided in the middle by a triangular fissure. Dorsal valve very slightly convex, almost flat; surface marked by numerous fine, thread-like bifurcating striæ, or with a smaller and shorter one between each of the larger pair. In the interior of the ventral valve there is a small tooth on either side of the base of the fissure, while the muscular impressions form a small saucer-shaped depression surrounded by a raised margin; this depression is about as wide as long, or about one fourth of the width of the shell, notched in front, and divided along the middle by a broad angular ridge. In the interior of the dorsal valve there exists a small bilobed cardinal process; slightly projecting, deviating, socket-ridges are also visible. Under the cardinal process a raised hollow, roof-like ridge extends to a little distance before becoming forked; on either side of the ridge are situated the muscular scars.

Obs.—Several internal casts, as well as an external impression, of this interesting species have been found by Mr. Vicary. It bears a good deal of resemblance to the *Leptæna Dutertrii* from the Devonian Limestone of Ferques, near Boulogne-sur-Mer, both in its exterior shape and interior arrangements, and I believe it to be a Devonian species. I have named it after my friend Major Wyatt-Edgell, to whom we are indebted for the discovery and publication of several interesting Budleigh species and specimens.

23. Strophomena Budleighensis, *Dav.* B. S. Sup., Pl. XXXIX, figs. 4, 4 *a*, *b*.

Strophomena Budleighensis, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 86, pl. iv, fig. 1, 1869.

Of this species a remarkable internal cast of the ventral valve was figured and described by myself in 1869. Since then no additional examples seem to have been found. It is convex, semicircular, and about as wide as long, or a little longer than the width of the shell. Area moderately wide, marked with perpendicular parallel lines, and with two deep circular pits (elevations on the cast), one on each side of the centre, divided by a small flattened space. The saucer-shaped muscular scars are large, and, in the shell, divided by a median ridge.

Mr. Vicary found this single specimen associated with *Rh. ovalis*. The peculiar shape of its area and the accompanying pits seem to distinguish it from other known forms of the genus, although it is impossible to offer a complete description of its characters.

24. Strophomena Etheridgii, *Dav.* B. S. Sup., Pl. XXXIX, figs. 10, 11.

Strophomena Etheridgii, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 85, pl. vi, figs. 10—12, 1869.

Semicircular, as wide as, or rather wider than long; hinge-line a little shorter than the width of the shell; ventral valve very slightly convex; area narrow; muscular impressions forming a large saucer-shaped depression, laterally margined by a slightly raised border, and longitudinally divided along the middle by a narrow ridge. In the interior of the ventral valve the hinge-area is linear, with a minute cardinal process in the centre; under this is situated a small oval-shaped depression, with another small pit on either side, while beyond there may be seen the small hollow for the reception of the teeth of the ventral valve. Under the three central depressions above described there exists a short raised mesial ridge, broad at its origin, but becoming gradually attenuated as it approaches its anterior termination; between this and the hinge-line are seen two granular ovarian elevations. The muscular impressions are indistinct. Exterior surface not known, in all probability finely radiatedly striated.

Length 11, width 12 lines.

Of this interesting species I have seen but two internal casts. It was found by Mr. Vicary along with *S. Edgelliana*, and is in all probability a Devonian species.

25. Strophomena, sp. ? Dav., B. S. Sup., Pl. XXXIX, fig. 1 *a*, *b*.

Semicircular, wider than long; hinge-line straight; ventral valve slightly convex, covered with very fine, thread-like, radiating striæ, with a shorter one between the larger pair.

Length 8, width 11 lines.

On the internal cast of ventral valve the muscular impressions cover upwards of a third of the breadth of the valve and half of its length. The area is narrow. In the internal cast of dorsal valve there exists, under a very small cardinal process, a small pit and two smaller lateral ones. A short median ridge extends from under cardinal process to a little distance, and on either side are situated the muscular impressions.

Only one specimen of this species has been found by Major Wyatt-Edgell, and presented by him to the Museum of Practical Geology, I have not ventured on giving it a specific name, and describe and figure the fossil for reference sake.

26. Strophomena, sp. ? Dav., B. S. Sup., Pl. XXXIX, figs. 2, 2 *a*.

Only one internal cast of this fossil has been found in the Budleigh-Salterton pebbles: it belongs to the Museum of Practical Geology.

The shell is semicircular; hinge-line straight, a little shorter than the breadth of the shell; area narrow and denticulated on all its extent.

Length 5, width 7 lines.

It seems to differ from all the other species I have seen from the locality, but the material is not sufficiently complete to warrant us at arriving at a specific identification.

27. Streptorhynchus crenistria? *Phil.* Dav., B. S. Sup., Pl. XXXIX, fig. 3.

Streptorhynchus crenistria, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 87, pl. v, fig. 26, 1869.

Of this species only a fragment of the exterior of one valve has been found. It seems to agree entirely with similar portions of *S. crenistria*, with which we have compared it. The shell has been fully described in my Monograph, as well as in the Carboniferous Supplement. It was found along with *Spirifera Verneuilii*, *Rhynch. inaurita*, and *Productus Vicaryi*, and is consequently a Devonian fossil.

28. Productus Vicaryi, *Salter*, sp. Dav., B. S. Sup., Pl. XXXIX, figs. 14, 15.

Leptæna Vicaryi, *Salter*. Quart. Journ. Geol. Soc., vol. xx, p, 296, pl. xvii, figs. 16, 17, 1863.

Productus — *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 87, pl. vi, fig. 14, 1869.

Shell sub-hemispherical, semicircular, slightly broader than long; hinge-line straight, shorter than the breadth of shell. Ventral valve convex, regularly vaulted; beak small, incurved; surface smooth, with irregular scattered tubular spines, more numerous on the ears. In the interior of the valve the large cardinal or divaricator scars are well marked, and widely separated one from the other. Dorsal valve not known; two specimens measured—

Length 12, width 13 lines.

„ 8, „ 9 „

Obs.—Internal casts of the ventral valve were well described and figured by Mr. Salter, but incorrectly identified by him as a *Leptæna*, while its external and internal characters show it to be a *Productus*. In his description he says: "I know no Silurian species, except the small *L. quadrata*, of Russia, and *L. tenuicincta*, of Britain, which resembles this in form. Both are much smaller and less gibbous." The Budleigh specimens, however, do not resemble the Russian species above referred to, nor do they belong to the same genus.

Mr. W. Linford has recently found an impression of the exterior of the ventral valve of the shell under description, in which the hollows left by the spines are preserved (fig. 14). *Productus Vicaryi*, in the shape and character of its spines so nearly resembles *Productus subaculeatus* that it is very possible that it may be hereafter necessary to refer the Budleigh-Salterton specimens to that species.

Productus Vicaryi is not very rare in the quartzite pebbles at Budleigh-Salterton, and is found associated with *Spirifera Verneuilii*, *Rh. inaurita*, and *Streptorhynchus crenistria*, as well as with other well-known Devonian species.

29. Chonetes, sp.? Dav., B. S. Sup., Pl. XXXIX, figs. 12, 13.

Chonetes, sp., *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 87, pl. vi, fig. 13, 1869.

Of this small species of *Chonetes* several specimens have been met with by Messrs. Edgell and Vicary in one or two pebbles, associated with *Rhynchonella inaurita*. It is no doubt of Devonian age. As the exterior has not been discovered, it would not be safe to refer it to any of the described species. The casts are marginally semicircular; hinge-line straight, with acute, slightly projecting cardinal angles; ventral valve evenly convex.

Length 3, width 4 lines.

In external shape it resembles some Devonian casts of *C. Hardrensis;* but, it is a smaller shell.

30. Crania transversa, *Dav.* B. S. Sup., Pl. XL, figs. 9, 10.

Crania transversa, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, pl. iv, figs. 9, 10, 1869.

Shell oblong-oval, widest anteriorly; upper valve moderately convex; ventral valve about one third the length of the shell from the posterior margin; surface smooth or marked by concentric lines of growth.

Length 6, width 7 lines.

Of this shell Mr. Vicary has found two examples. Externally it resembles more than one Devonian, as well as Carboniferous species. The interior not having been found, it cannot be critically described. It is a Devonian species, for it has been found in the same pebble with *Rhyn. inaurita*, Sandb.

31. Discina Vicaryi, *Dav.* Sil. Mon., Pl. VII, fig. 13; B. S. Sup., Pl. XL, figs. 11—13.

At p. 67 of my Silurian Monograph I figured and described this species, stating at the same time that I could not say whether it was a Devonian or a Silurian species. That uncertainty still prevails, because no other known Brachiopod has been found along with it in the same pebble. Two or three additional specimens have been found since I described the shell in 1866; and Mr. Vicary has picked up a reddish quartzite pebble, exactly similar to those that occur at Budleigh-Salterton, on the Chisel Bank, containing a specimen of this fossil, and of this a figure is given in Pl. XL, fig. 13. It bears resemblance to the *Orbicula Daleidensis*, Schnur ('Eifel. Brachiopoden,' tab. xliii, fig. 7), a Devonian species.

32. Discina incerta, *Dav.* B. S. Sup., Pl. XL, figs. 14, 15.

Discina incerta, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 77, pl. iv, fig. 7, 1869.

Shell nearly orbicular; apex one third of the diameter from the margin; upper valve moderately convex.

Length $3\frac{1}{2}$, breadth 3, height 1 line.

Of this small species I have seen several specimens from Budleigh-Salterton; but, as no other fossil has occurred along with it in the same pebble, I cannot say whether it is a Devonian or a Silurian species.

33. Discina ? Edgelli, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 78, pl. iv, fig. 8, 1869.

In the 'Quart. Journ. of the Geol. Soc.,' I gave a figure of an almost circular shell, much depressed and smooth. It has much of the external shape of an *Obolus*, but the material was not sufficient to enable me to refer it to any species with which I was acquainted.

LOWER SILURIAN SPECIES.

1. Species referable to the Age of the "Grès de May" or Caradoc.

34. Lingula Morierei, *Tromelin*. Dav., Sil. Mon., Pl. I, fig. 31; and B. S. Sup., Pl. XL, figs. 25, 26.

Lingula morierei, *Trom.* Foss. paléozoïques (Tableau D), No. 65, 1876; and Bull. Soc. Linn. de Normandy, 3rd ser., vol. i, p. 55, 1877.

Shell marginally oval, widest and rounded anteriorly, longer than wide, moderately convex.

Length 1 inch, breadth 7 lines.

Obs.—When publishing my Silurian Monograph I had but one specimen of this species to examine, and did not dare give it a specific name. Since then M. de Tromelin, having also obtained a single specimen in the "Grès de May" at May, in Normandy, described it under the name of *Lingula Morierei*. It seems distinct from the species that occur in the "Armorican Sandstone."

Mr. Vicary has since then found at Budleigh-Salterton two more examples, which seem referable to the same species (figs. 25 and 26 of our plate); one of them is an internal cast of the ventral valve, showing the central muscular scars. M. de Tromelin states that there exists a strong longitudinal, median convexity in the posterior half of the only valve with which he is acquainted, and a similar convexity occurs in the specimen figured in my Silurian Monograph.

35. Terebratula ?, sp. B. S. Sup., Pl. XLI, fig. 23.

Terebratula? sp., *Dav.* Notes on the Brach. hitherto obtained from the Pebble-bed of Budleigh-Salterton—Quart. Journ. Geol. Soc., vol. xxvi, p. 78, pl. iv, fig. 11, 1869.

The exterior of a ventral valve only having been discovered it would not be safe to give the shell a specific name. We have put it provisionally with *Terebratula*. It is marginally longitudinally oval, tapering at the beak, widest and rounded anteriorly, convex, smooth, and marked only by a few concentric lines of growth.

Length 8, width 4 lines.

It bears some resemblance to the *T. inæqualis* of Roemer ('Beitr. zu Kenntniss der

Nordwestlichen Harzgebirge, pl. iii, fig. 3), a form belonging to the Silurian Spirifer-sandstone. This specimen was kindly lent to me by Mr. Vicary. It occurs in a slightly reddish light grey quartzite pebble, in company with *Orthis Budleighensis* and a fragment of Trilobite.

36. Nucleospira Vicaryi, *Dav.* B. S. Sup., Pl. XL, figs. 29—31.

Nucleospira Vicaryi, *Dav.* Quart. Journ. Geol. Soc., vol. xxvi, p. 79, pl. iv, figs. 15—18, 1869.

Shell transversely suborbicular; valves very moderately convex, more so near the beaks. In dorsal valve mesial fold wide, of small elevation, rising towards the front. Surface smooth, marked by a few concentric lines of growth. In the interior of dorsal valve the bifid cardinal process projects considerably, while under it rises a narrow ridge, which extends straight to the front, dividing the interior of the valve into two equal portions. The muscular impressions are situated on either side of the posterior half of the ridge. In the interior of the ventral valve a similar mesial longitudinal ridge is also present, which, as in the case of the dorsal valve, divides the valve into two equal parts. Two examples measured respectively—

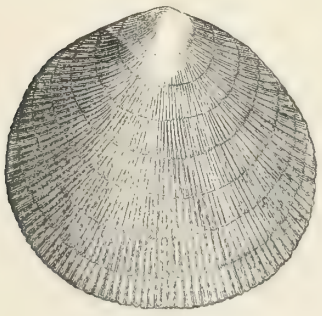
Length 7, breadth 9, depth 2 lines.
„ 5, „ 6 lines.

Obs.—I described this shell in 1869, and no fresh material seems to have turned up since that period. It seems referable to the genus *Nucleospira*, Hall; and approaches by its size and character to *N. elegans*, Hall ('Pal. New York,' vol. iii, p. 222, pl. xxviii B, figs. 10 and 15). It bears also some resemblance to *N. ventricosa*, Hall. It varies in shape, some examples being almost circular, while others are more or less transversely oval. *N. Vicaryi* is not rare in certain pebbles; no less than thirty-five specimens, representing different ages, having been collected by Mr. Vicary. It is of the age of the "Caradoc" pebbles; for at Budleigh-Salterton it is associated with an *Orthis* resembling *O. Budleighensis*. In America *N. elegans* belongs to the Lower-Helderberg Rocks, and an allied form, *N.* (*Spirif.*) *pisum*, Sow., is not rare in our British Upper-Silurian strata.

37. Orthis Berthoisi, *Rouault.* Bull. Soc. Géol. de France, 2nd ser., vol. vi, p. 68, 69, pl. ii, figs. 4 *a*, *b*, *c*, 1848.

So much discussion and divergence of opinion having taken place and been expressed with respect to this species, that I think it will be desirable to begin by giving a trans-

lation of the description Rouault gave of his shell. "It is a large shell of the arcuato-striata group of M. de Verneuil, not very thick; its dorsal valve moderately convex, with a slightly projecting beak; both valves are covered with very numerous, fine, radiating striæ and well-marked concentric lines of growth. The most prominent character, however, and at the same time the most difficult to define in a specific description, is furnished by the numerous deformations it has undergone; these deformations are such that, out of more than sixty specimens, it has been impossible to find two alike, although they all belong to a species of which the symmetrical form is well recognised." M. Rouault's type example, the one figured above, measures—



Orthis Berthoisi, type.
M. Rouault's figure. Slates of La Couyère.

Length 19, breadth 19 lines.

Of this species I have seen a number of specimens from La Couyère, the same locality from whence M. Rouault obtained his types. They all occur in black slates, and are flattened by compression. Some show the exterior; others are internal casts, on which the muscular scars are visible. These slates occur above the "Grès Armoricain" and under the "Grès de May." As far as my knowledge goes, we have not found in England slates with specimens of this large *Orthis*.

38. Orthis Berthoisi, var. erratica, *Dav.* Sil. Mon., p. 233, Pl. XXXII, figs. 21—28; B. S. Sup., Pl. XLI, figs. 1—9.

This shell has been fully described and illustrated in my Silurian Monograph; but, as some better examples have turned up, it has been considered desirable to add figures of a few of them to this Supplement, as well as to give some further details with respect to its character and history.

As has been already stated at p. 234 of my Monograph, Mr. D. Sharpe, in 1853, described and figured an *Orthis*, from the Lower-Silurian Rocks of Portugal, under the name of *O. Berthoisi*, Rouault. It is very variable in shape, as may be seen from the good series of Portuguese specimens in the possession of the Geological Society of London; but it is a much smaller shell than Rouault's typical form from the slates of La Couyère, not being more than half its size; and in this respect it agrees completely with the specimens that are found in the quartzite pebbles of Budleigh-Salterton. In the gritty, hard sandstones of St. Germain-sur-Ille, and of La Bouëxière, as well as in the reddish quartzites of May, in Normandy, there occur vast numbers of a shell exactly similar to those that are found in Portugal and at Budleigh-Salterton. This rock is higher up in the

series than that of the slates of La Couyère, and I still consider it a smaller variety of *O. Berthoisi*, and to which I have given the varietal name of *erratica*.

In the memoir, 'Congrès de Nantes,' 1878, and at p. 506 of the 'Bulletin of the Geological Society of France,' 3rd ser., vol. iv, 1876, MM. de Tromelin and Lebesconte admit the varietal name of *erratica* for the shell under description. M. de Tromelin states that the fossil is extremely rare in the quartzite of May, having found but a single example, while at St. Germain-sur-Ille it is exceedingly abundant in the shape of internal casts and impressions of the exterior, but almost every example is compressed and out of its natural shape from fossilisation. This variety, according to M. de Tromelin, and in this view I fully coincide, entirely agrees, with that found in the Portuguese rocks above mentioned. The ventral valve in many well-preserved specimens of the var. *erratica* is almost flat, with or without a slight depression, commencing about the middle of the shell, and extending to the front.

39. Orthis pulvinata, *Salter*. B. S. Sup., Pl. XLI, figs. 10, 11.

Orthis pulvinata, *Salter*. Quart. Journ. Geol. Soc., vol. xx, p. 294, pl. xvii, fig. 8, 1860.
— — *Dav*. Quart. Journ. Geol. Soc., vol. xxvi, pl. v, figs. 17—19, 1869.

Transversely oval; hinge-line shorter than the width of the shell; valves uniformly and moderately convex; surface marked by fine, radiating, thread-like striæ, increasing in number towards the margin by the interpolation of shorter striæ. Area narrow; the internal cast of the ventral valve shows a large saucer-shaped muscular area, divided by a widish, slightly-raised, flattened ridge. In the internal cast of the dorsal valve there is a narrow longitudinal split, margined by a raised, rounded rim, under which are placed in pairs, one above the other, the quadruple elevations due to the adductor muscle, and longitudinally separated by a narrow concave space (see Pl. XLI, figs. 11 and 11 *a*). Dimensions variable.

Length 11, breadth 14 lines.

Obs.—The internal cast of the dorsal valve, the one we have drawn, was in 1863 described and figured by Salter, the exterior and interior of the other valve being unknown to him at the time; subsequently, however, impressions of the exterior, as well as the internal cast of the ventral valve, were found by Mr. Vicary, so that it became possible to draw up a complete description of the species.

M. de Tromelin and some other palæontologists seem disposed to consider *O. pulvinata* a transverse form of *O. Berthoisi*, var. *erratica*; but when you compare the figures of the interior of the dorsal valve (fig. 11 *a*) with that of *O. Berthoisi*, var. *erratica* (fig. 8 *b*), a great difference is at once discernible. I am also disposed to consider it probable that

Salter's "*Porambonites*," sp. ('Quarterly Journal Geol. Soc.,' vol. xx, p. 295, pl. xvii, fig. 9), may be a large internal cast of the dorsal valve of *O. pulvinata*.

O. pulvinata is not nearly so abundant as *O. Berthoisi*, var. *erratica*, in the Sandstone and quartzite pebbles of Budleigh-Salterton. M. de Tromelin informs me that *O. pulvinata* occurs in company with *O. Berthoisi*, var. *erratica*, at Saint Germain-sur-Ille, La Bouëxiere, Champeaux (Ille-de-Vilaine), and in other places.

40. Orthis Budleighensis, *Dav.* Sil. Mon., p. 224, Pl. XXVIII, figs. 6—9 (as *O. redux*); B. S. Sup., Pl. XLI, figs. 12—20; and Pl. XLII, figs. 16—25.

This species has given M. de Tromelin and myself very much trouble, research, and uncertainty; and several so termed distinct species, evidently the same, have received different names, so that much confusion has ensued. I am not yet satisfied that it may or may not be the *Orthis Filiceræi* of Rouault;[1] never having seen any of the Vitré specimens, and no figure of the species having been given by M. Rouault, I cannot speak positively either one way or the other. Although M. de Tromelin believes that *O. Budleighensis* is the same as *O. Filiceræi*, he states in his memoir, "Études de la Faune du Grès Silurien de May, Jurques, Campandre, Mont-Robert, &c., Calvados," 'Bull. de la Soc. Linn. de Normandie,' 3 ser., vol. i, 1876-7, that unfortunately the specimens found in the schists of Vitré are very much out of shape. I will, therefore, at any rate provisionally, continue to make use of the name *Budleighensis*, as the characters of the species so named have been very clearly defined on a multitude of perfectly preserved specimens.

So like, indeed, are some examples of *O. Budleighensis* to *Orthis testudinaria* of Dalman, that it has been identified with it by several palæontologists.[2] Feeling very uncertain upon the subject, I forwarded to Prof. Lindström a number of casts of *O. Budleighensis* from May and Budleigh-Salterton, and asked him to compare them attentively with Dalman's series of typical examples of *O. testudinaria* from the Lower Silurian marl of Borenshult, in Ostrogovia, that are preserved in the Museum of Stockholm; and his reply was: "I cannot decidedly say that the English specimens are identical with Dalman's *O. testudinaria*; they are more finely striated and more trans-

[1] 'Bull. Soc. Géol. de France,' 2nd ser., vol. viii, p. 366, 1851:—"*Orthis Filiceræi*, Marie Rouault: La forme de cette petite espèce est presque circulaire. L'area est néanmoins assez développé en largeur; la valve dorsale [this is the ventral one of modern palæontologists] est convexe à l'endroit du crochet qui est très marqué, celle ventrale [our dorsal] de forme plus applatie; toutes deux sont couvertes par des stries larges et trés saillantes, dichotomées près du bord et non arquées sur les côtes. Localité—Vitré."

[2] In their memoir, "Sur la Géologie d'Almaden, Spain" ('Bull. Soc. Géol. de France,' 2nd ser., vol. xii), MM. de Verneuil and Barrande describe, under the name of *Orthis testudinaria*, Dal. (pl. xxvii, fig. 9, 1856), an *Orthis* identical with the *O. Budleighensis* of May and Budleigh-Salterton, and add *O. Bussacensis*, Sharpe, as a synonym.

verse. At the utmost I would put them down as a variety of *O. testudinaria,* but I do not feel I am quite justified in doing so." Prof. Lindström, in order to assist me in my examination, kindly forwarded to Brighton three of Dalman's typical specimens, and I give a figure of one of them for reference, see fig. 26 of the Plate XLII, devoted to Cornish Lower-Silurian species.

In 1864 Mr. Salter identified the species under description with the *Orthis redux* of Barrande. At p. 224 of my Silurian Monograph I followed the same erroneous view, but in 1869 ('Quart. Journal Geol. Soc.,' vol. xxvi, p. 83) I said, "although this shell was identified by Mr. Salter with *O. redux* (Barrande), both M. de Verneuil and myself entertain misgivings as to the correctness of the identification. The Bohemian Silurian species is not well known; the internal cast only has been figured by Barrande." I then proposed to name the shell *Orthis redux*, Barrande? var. *Budleighensis.*

In 1877 M. de Tromelin observes, in his paper already referred to, that he had, up to 1877, in accordance with the views of every other author, considered the *Orthis* that occurs at May, in Normandy, as a local type of *O. redux*, while expressing doubt as to the correctness or reality of the identification; that since then, by the inspection of real Bohemian specimens of *O. redux*, he had found that his doubts were well founded, and consequently that in his new publications he had retained for the species of May the specific name of *Budleighensis,* which I had given to it when supposing it a variety of *O. redux;* and in a subsequent letter he informs me that in *Orthis redux* the smaller dorsal valve is much more convex, the striæ much more equal or uniform in size, and the interiors very different,[1] Having obtained, through the liberality of M. Barrande, four examples of his *O. redux*, I was able to fully confirm the statements and views expressed by M. de Tromelin upon the subject.

Orthis Budleighensis is very variable in shape. It is sometimes marginally quite circular, and as broad as long (B. S. Sup., Pl. XLI, fig. 15), and in that condition seems to be undistinguishable from *Orthis testudinaria;* but it is more often transverse, or wider than long, and some examples in that condition are exactly similar to the figure given by Sharpe in the 'Quarterly Journal of the Geological Society of London,' vol. ix, pl. viii, fig. 3, 1853, of his *Orthis Bussacensis;* but other specimens of the same species in the collection from Portugal, in the Museum of the Geological Society of London, are so very much larger than any of the May or Budleigh-Salterton specimens of *O. Budleighensis* that I could not feel certain as to their identity. The largest specimen of *Orthis Budleighensis* I have seen from May and Budleigh-Salterton measured—length $6\frac{1}{2}$, breadth 9 lines.

[1] In his memoir on the 'Sandstones of May,' above quoted, at p. 78 M. de Tromelin gives the following list of the Brachiopoda he had obtained from that celebrated locality, viz.:—1. *Lingula Morierei,* Trom. 2. *Orthis Budleighensis,* Dav. 3. *O. Berthoisi,* var. *erratica,* Dav. 4. *O. exornata,* Sharpe. He did not find the true *O. redux* of Barrande at May; but he states that he found one specimen referable to the species at the Brèche-au-Diable, in Normandy, as well as some in similar beds at St. Germain, La Bouëxière, and Champèaux, in Brittany, where the species is not uncommon.

Mr. Sharpe's figured specimen of *O. Bussacensis* measured—length 6, breadth 9 lines. They may, however, be variations of a same species.

The striation in *O. Budleighensis* varies also in different specimens, being closer, finer, and more uniform in some examples, while in others the shorter and smaller striæ between each pair of the larger ones are more apparent. M. de Tromelin writes me that in Bohemia M. Barrande refers one of his species from his horizon *d* 5 to *Orthis testudinaria* of Dalman, but with a mark of doubt, that he has seen the specimens so identified by the celebrated French palæontologist, and that he believes them to agree with the *O. Filiceræi* of Rouault, or *Budleighensis*.

Orthis Budleighensis is the most abundant fossil in the Caradoc pebbles of Budleigh-Salterton. Dr. Carter, of that place, informs me that a pebble covered with impressions of the exterior and internal casts of this species, found by himself in 1835 (and which he has kindly presented to me), was perhaps the first intimation of the presence of organic remains in the quartzite pebbles of the Old Beach at Budleigh that was ever recognised. This *Orthis* occurs also *in sitú* in light grey quartzite at Gorran Haven, in Cornwall, where it was found by Mr. C. W. Peach, the first discoverer of fossils in the Cornish Lower-Silurian Rocks. Other specimens were subsequently found there by Mr. R. Etheridge, and deposited in the Museum of Practical Geology in London. Similar quartzite pebbles in the Drift, and containing the same fossil, have been found by Mr. Perceval at Sparkbrook, near Moseley, Birmingham, by Mr. W. J. Harrison at Counterthorpe, about five miles south of Leicester, by Mr. Jennings near Nottingham, and by the Rev. P. B. Brodie in the Drift near Warwick. In his able memoir, published in the first volume of the third series of the Société Linnéenne de Normandie, at p. 67, M. de Tromelin says:

"It is known that *O. Budleighensis* fills of itself whole beds at May, Jurques, Campandré, Mont Robert (La Brèche-au-Diable), but that at May the beds that contain this species in abundance are below those that contain the greater number of species of the locality. There is no reason, however, to believe that these beds constitute a distinct zone; for associated with these occur other fossils: also that *O. Budleighensis* is less abundant in the sandstones of the North of the Department of the Ille-et-Vilaine than in those of the Calvados; that he has picked it up in Brittany, at St. Germain-sur-Ille, La Lande de Baugi, La Bouëxière, Champeaux, &c; that there exists in the slaty schists a species which he has found it impossible to distinguish from *O. Budleighensis;* that it is very abundant at Domfront, and at Andouillè; and that the specimens from those localities cannot be distinguished from those of Bohemia, 'bande *d* 5,' provisionally referred to *O. testudinaria*. The same species occurs at La Hunandière (Loire-Inférieure); Morgat, near Crozon (Finistère); St. Denis d'Orgues; at La Butte du Creux (Sarthe); Brieux (Orne), &c."

41. Orthis Valpyana, *Dav.* Sil. Mon., Pl. XXXII, figs. 29—33; B. S. Sup., Pl. XLI, figs. 21, 22.

I have nothing to add to the description of this species given at p. 235 of my Silurian Monograph.

Orthis exornata, Sharpe ('Quarterly Journal of the Geol. Soc.,' vol. ix, p. 153, pl. viii, fig. 2), is stated by M. de Tromelin to occur at Budleigh-Salterton ('Bull. Soc. Géol. de France,' 3rd ser., vol. iv, p. 596, 1877), but I did not find it in any of the many collections of specimens from that place, which have passed through my hands for examination; and consequently I quote it as a Budleigh-Salterton fossil on M. de Tromelin's authority. The same geologist states that this species is not very rare at La Bouëxière; that it likewise occurs, but more rarely, at St. Germain and at Champeaux, and in the quartzites of May, in Normandy. In Portugal it is quoted by Sharpe from the Lower Silurian at Sazes, and Porto de Santa Anna, in the Serra de Bussaco.

I regret that, M. de Tromelin having mislaid his Budleigh-Salterton specimen, I have not been able to see it or to give a figure of it.

LOWER SILURIAN SPECIES.

2. Species referable to the Age of the "Grès Armoricain," Rouault, and which M. Gaston de Tromelin refers to the lowest portion of the Llandeilo, or even, perhaps, to the "Stiper Stones."

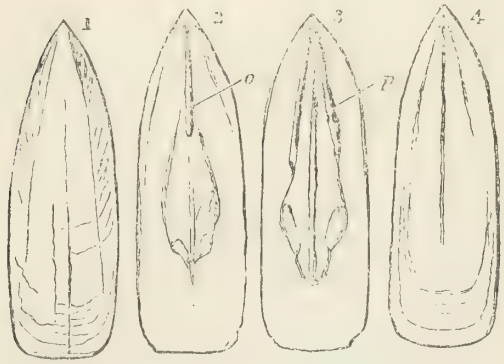
42. Lingula? Lesueuri, *Rouault.* Dav., Sil. Mon., Pl. I, figs. 1—11; B. S. Sup., Pl. XL, figs. 16—20.

Lingula Lesueuri, *Rouault.* Bull. Soc. Géol. de France, 2nd. ser., vol. vii, p. 727, 1850.[1]

— ? — *Dav.* Geological Magazine, new series, vol. vii, p. 341, pl. x, fig. 7, 1880.

[1] "Coquille mince, très allongée, tronquée carrement en avant; les parties laterales du bord representent deux lignes droites; formant avec celle antérieure des angles droits à peine émoussés; ces parties latérales du bord ne présentent qu'une faible courbure en venant gagner la charnière; ce qui donne à la coquille une forme générale très symétrique. Elle est couverte sur toute sa surface de lignes d'accroissment très nombreuses et très marquées; quelques unes, de distance en distance, le sont davantage. Ces stries sont croisées par d'autres longitudinales très fines et très serrées. Localité—Guichen."

This very interesting species is now well known, but it has been questioned by M. de Tromelin whether it is a true *Lingula*. In external, shape, size, and character, it closely resembles *Glottidia Palmieri*, Dall., a shell that lives in the Gulf of California, and is characterised by the presence of a median septum in the interior of the ventral valve (fig. 2 *o*), and two diverging ones in the dorsal valves (fig. 3 *p*), so that were the recent form fossilised it would be hard to distinguish it from the Lower-Silurian *L. Lesueuri*. In their memoir, 'Essai d'un Catalogue raisonné des fossiles Siluriens des Départements de Maine et Loire' (Congrès de Nantes, 1876), MM. de Tromelin and Lebesconte observe that some examples they have seen present a similar longitudinal mesial ridge in the ventral valve, and two diverging short ones in the dorsal valve. It must, therefore, remain for further consideration whether or not *L. Lesueuri* should be placed with *Glottidia*.



1—3. *Glottidia Palmieri*, Dall. 1. Exterior. 2. Interior of ventral valve, *o*, single septum. 3. Interior of dorsal valve, *p*, diverging septum.
4. *Lingula ? Lesueuri*. Internal cast.

5. *L. ? Lesueuri*, with peduncle. Budleigh.

Since describing this species at p. 42 of my Silurian Monograph, Mr. Vicary has found in a Budleigh-Salterton "pebble" a specimen with its complete peduncle. This is remarkable, but it is not the first time that the peduncle of a Brachiopod has been found preserved in the fossil condition. If the reader will turn to p. 192 of my Silurian Monograph he will find a figure of the peduncle of *Eichwaldia subtrigonalis*, Billings, completely preserved in the fossil condition.

Lingula Lesueuri is not an extremely common fossil in the "Grès Armoricain" at Pontréan, Guichen, and Sion, in Brittany. It has also been found at Chateaubriant. In his note on the Grès de Bagnoles (Orne), 'Bull. Soc. Linn. de Normandie,' 3rd ser., vol. ii, p. 22, M. Morière states that he found the shell in the Grès Armoricain of that locality along with *Lingula Brimonti*, *Lingula Salteri*, and *Lingula Hawkei*. M. de Tromelin informs me that he likewise discovered the shell under description at Lairoles, near Roquebrun, in the Parish of St. Pons, Département of Hérault. M. Barrois informs me that he found it likewise at St. Denis d'Orgues. We may also mention that the Rev. P. B. Brodie picked up a specimen of this *Lingula* in a quartzite pebble similar to what occurs at Budleigh-Salterton, in the Drift of Warwickshire, and another was collected in the Drift at Ladypool Lane, near Birmingham, by Mr. Houghton, and presented by him to the Cambridge Woodwardian Museum (Sup., Pl. XL, fig. 19).

Lanceolate forms of *Lingula*, very near in shape to *L. Lesueuri*, have received different names.

43. Lingula ? Hawkei, *Rouault.* Dav., Sil. Mon., Pl. I, figs. 14—20 (as *L. Rouaulti*); B. S. Sup., Pl. XL, fig. 21 and 27 ?.

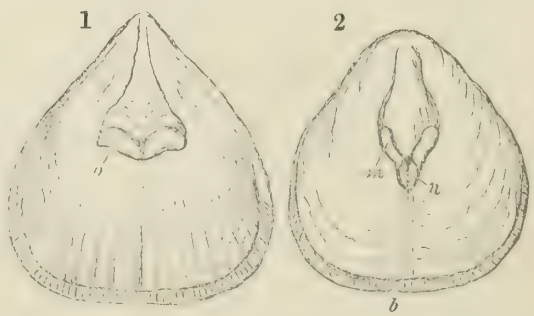
Lingula Hawkei, *Rouault.* Bull. Soc. Géol. de France, 2nd ser., vol. vii, p. 728, 1850.[1]

— Rouaulti, *Salter.* Quart. Journ. Geol. Soc., vol. xx, pl. xv, figs. 2, 3, 4, 1864; and Dav., Sil. Mon., pl. i, figs. 14, 20, 1866.

— Hawkei, *de Tromelin.* Congrès de Nantes, 1876.

— ? — *Dav.* Geol. Mag., new ser., vol. vii, p. 342, pl. x, figs. 8—11, 1880.

MM. de Tromelin and Lebesconte state, in their paper above referred to, that the shell to which Mr. Salter gave the name of *Ling. Rouaulti* is Rouault's *L. Hawkei.* Mr. Salter was, no doubt, as well as myself, misled by Rouault stating that his shell was nearly circular, while in reality *Lingula Hawkei,* is marginally pear-shaped, tapering considerably on the margin from about the middle to the extremity of the beak. I also think he must have considered the shell I described subsequently as *Lingula Salteri* the same; for he describes the exterior surface of his species as being covered with very fine and close radiating striæ. Some remarkably well-preserved internal casts from Pontréan, lent by M. Lebesconte, show a flattened margin all round the inside of the edge of the shell, of about one line in breadth; also in the dorsal valve a deepish depression or sinus (in the cast), commencing at about half the length of the valve and extending to the inner edge of the flattened margin (*b*), and which in the interior of the valve itself must have formed an elevation. Two well-defined muscular impressions occupy the central portion of the valve (fig. 1, *a*). The surface of the internal cast is also finely longitudinally striated; and no doubt this is the striation, and not that on the exterior surface of the valves, which M. Rouault saw and described. On the internal cast of the dorsal valve the centre is occupied by V-shaped muscular scars (*m* and *n*, fig. 2), which would be the



Lingula Hawkei, Rouault.

1. Internal cast of ventral valve: *a*, muscular impression; *b*, flattened margin.

2. Internal cast of dorsal valve: *c*, muscular scars; *b*, flattened margin.

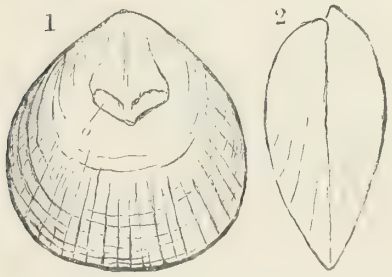
[1] "Coquille de forme presque arrondie; un peu plus longue que large, plus developpée en avant; renflée vers le haut; s'amincissant vers le bord, sans côtes à sa surface; lignes d'accroissement très marquées croisées par d'autres longitudinales; fines et très serrées. Se distingue de *L. dubia,* d'Orb., par sa forme plus allongée et son plus grand développement, et de *L. quadrata,* Eichwald, par sa largeur, qui est plus grande en avant, et beaucoup moindre en venant gagner la charnière. Longeur 42 millimètres, largeur 38 millimètres, epaisseur 20 millimètres. Localité—Guichen."

same as the central muscles (which close the valves), and lateral anterior muscles, which in *Lingula* enable the valves to move forward and backward on each other. No indications of transmedial or sliding muscles could be detected on any of the internal casts I have been able to examine. As far as I could see, from the specimens placed at my disposal for examination, the exterior surface of the valves was smooth and marked only by concentric lines of growth. A large specimen measured 18 lines in length by 16 in breadth; but I believe the species sometimes exceeded those dimensions. M. Caillard mentions its presence at Sion, and M. de Tromelin observes that it is not rare in Brittany, and that he found it also at Soulvache (Seine Inférieure). M. Barrois collected the fossil at Chemiré in Charnie. In the Albert Memorial Museum, at Exeter, may be seen an internal cast showing both valves, the muscular impressions being sharply defined on the surface corresponding to the ventral valve (Sup., Pl. XL, fig. 21). We may also state that occasionally we meet with a specimen so very much attenuated posteriorly as to simulate *Lingula crumena*, an Upper-Llandovery species, as is exemplified by the figure, Sup. Pl. XL, fig. 27 : the specimen is in the Museum of Practical Geology.

44. Lingula? Salteri, *Dav.* Sil. Mon., Pl. I, figs. 27—29; and B. S. Sup., Pl. XL, fig. 24.

Lingula ? Salteri, *Dav.* Geol. Mag., new series, vol. vii, p. 342, pl. x, figs. 12, 13, 1880.

The material afforded by the Budleigh-Salterton pebbles is much inferior to that obtainable from the "Grés Armoricain" at Pontréan, in Brittany. One perfect example in M. Lebesconte's collection measures 21 lines in length and breadth by 11 in depth, and shows that the shell was nearly circular, or about as broad as long, slightly indented or rounded in front. Valves moderately convex; a slight mesial longitudinal depression or sinus dividing the dorsal valve into two halves. The beak was of small projection, and seemingly incurved at its extremity. The surface of both valves, faintly and closely covered with fine thread-like radiating striæ, crossed at intervals by concentric lines of growth. In an internal cast of a ventral valve the muscular impressions are sharply defined, and agree in character with those we observe in *Lingula? Hawkei.*



1. Internal cast of ventral valve, from Pontrean, showing central muscular impression (*a*). 2. Profile of both valves.

45. Dinobolus Brimonti, *Rouault*, sp. Dav., Sil. Mon., Pl. I, figs. 21—26 (as *L. Hawkei*); B. S. Sup., Pl. XL, figs. 22, 23.

Lingula Brimonti, *Rouault*. Bull. Soc. Géol. de France, 2nd ser., vol. vii, p. 728, 1850.[1]

— Hawkei, *Salter* (not of Rouault). Quart. Journ. Geol. Soc., vol. xx, p. 294 pl. xvii, figs. 2, 3, 1863.

— Brimonti, *Salter*. Quart. Journ. Geol. Soc., vol. xx, p. 294, pl. xvii, fig. 6, 1863.

— Hawkei, *Dav.* (not of Rouault). Sil. Mon., p. 41, pl. i, figs. 21—26, 1866, and Quart. Journ. Geol. Soc., vol. xxvi, pl. iv, fig. 3, 1869.

— Brimonti, *de Tromelin*. Congrés de Nantes, 1878.

Dinobolus Brimonti, *Dav.* Geol. Mag., new ser., vol. vii, p. 340, pl. x, figs. 1—6 1880.

I never felt satisfied that Salter was correct while referring the specimen under description to the *Lingula Hawkei*, Rouault, and accordingly, at the time of publishing my Silurian Monograph, I wrote to M. Rouault upon the subject; but having received no reply to my communication, followed the view taken by Salter, adding, however, "I do not know whether our British specimens answer to the French description." In 1879 M. Gaston de Tromelin wrote me that, having been able to induce M. Rouault to show him his collection and types, he was able to assert that the shell Mr. Salter and myself had described and figured as the *Lingula Hawkei* was, in reality, Rouault's *Lingula Brimonti*. We were not, however, the only ones to misunderstand Rouault's species, for M. de Tromelin mentions, in his paper above named, that in most collections it bears the name of *L. Hawkei*. M. de Tromelin states, also, that the specimens from the Loire-Inférieure attain a large size, and that Cailliaud has alluded to the numerous deformations it has been subject to. In a letter he observes that the muscular impressions seem to differ so much in this species from those of *Lingula* or *Glottidia* that, in his opinion, it should constitute a new genus, a similar view being taken by Professor Bayle.

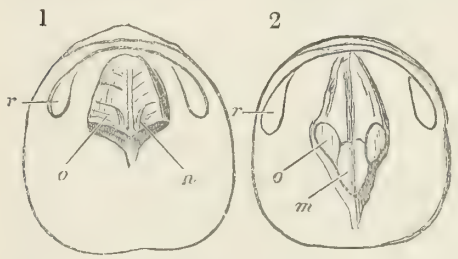
Thanks to the liberality of M. Lebesconte, of Rennes, and some other friends, I have been able to study a very extensive series of bivalve specimens also of well-preserved internal casts from Pontréan, in Brittany; and I at once perceived that the species

[1] "Longeur 40 mill.; largeur 46; épaisseur 25 millimetrès. Coquille courte, robuste, très renflée; la plus épaisse du genre; plus large que longue; tronquée brusquement en avant; bord parfaitement circulaire à partir des angles qu'il forme antérieurement jusqu'à la charnière, de laquelle part, en formant un crochet sur chaque valve, un renflement qui se divise en deux côtes très marquées qui viennent aboutir aux deux angles que forme le bord en avant. La coquille est en outre couverte sur toute sa surface de lignes d'accroissement très saillantes. Ne présente avec toutes les espèces connues que des rapports génériques. Localité—Guichen, Bain."

possessed all the interior characters of Hall's genus *Dinobolus*, of which genus Prof. King and myself had given an elaborately illustrated description in vol. xxx of the 'Quarterly Journal of the Geological Society' (1874). In August, 1880, I inserted an article upon the subject in the 'Geological Magazine.'

Bivalve specimens seem very scarce at Budleigh-Salterton, but in France they appear to be abundant, and so we had better complete our description of the species from the more complete French material.

Shell very variable in shape, marginally subquadrate, with anterior rounded angles and slightly indented front. Sometimes the shell is triangular, and widest anteriorly. Dorsal valve very convex and inflated, especially at the umbo, flattened at, and close to, the cardinal line and extremities. Ventral valve not so deep as the opposite one, with a longitudinal mesial depression on the anterior half of the valve; beak small and very little produced. Surface of valves smooth, and marked with numerous concentric lines or projecting ridges. On the interior surface of the ventral valve there exists a broad slightly raised platform (fig. 1), on which are situated the lateral and anterior muscular scars (*o* and *n*) as well as the crescent (*r*). On the interior surface of dorsal valve (fig. 2) the crescent (*r*) is well defined, as well as the V-shaped lateral and median scars (*o* and *m*). Dimensions very variable. Two specimens measured respectively—



Dinobolus Brimonti, Rouault, sp.

1. Interior of ventral valve: *o*, *n*, anterior median muscular scars; *r*, crescent.

2. Interior of dorsal valve: *r*, crescent; *o*, *m*, lateral and median muscular impressions.

Length 19, width 17, depth 13 lines.
,, 15, ,, 16, ,, 8 ,,

Dinobolus Brimonti does not appear to be a very abundant fossil in the Budleigh-Salterton pebbles. Abroad, in addition to Guichen and Bain, we may mention Pontréan, in Brittany, and in his memoir M. de Tromelin adds Châteaubriant. At the Butte des Kidais, Ruffigné, Sion, the shell attains to larger dimensions than in any other of the localities referred to; two examples measured respectively—length 20, width 24 lines; length 21, width 15, depth 16 lines. M. Morière found it also in the Grès de Bagnoles (Orne).[1] M. C. Barrois informs me that this fossil occurs also in the Meney-Hom Mountains.

[1] I may likewise observe that subsequent to the publication of the memoir by King and myself on the *Trimerellids*, Prof. Fred. Schmidt discovered in a light yellowish limestone at Laisholm, in Russia (his Schicht 5) a number of internal casts of a small species of *Trimerella*, and at Werden, in the same country (in his Schicht 6), a species of *Monomerella*. So that examples of this important family of Brachiopoda are now known from Sweden, Russia, France, England, Canada, and the United States, and will no doubt with time be found in other places. *Dinobolus Brimonti* is the most ancient representative of the genus with which we are at present acquainted.

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SUPPLEMENT, PLATE XXXVIII.

DEVONIAN.

FIG.

1—3. *Terebratula sacculus*, Martin, sp. 1. Collection of Mr. Linford. 2, 3. Internal cast in the collection of Mr. Vicary. Budleigh-Salterton. (P. 337.)

4. *Athyris ? erratica*, Dav. 4 *a*. Enlarged. Budleigh-Salterton. Collection of Mr. Vicary. Perhaps a Rhynchonella. Material not sufficient. (P. 338.)

5. „ *incerta*, Dav. One specimen only. Budleigh-Salterton. Collection of Mr. Vicary. (P. 338.)

6. „ *Budleighensis*, Dav. Budleigh-Salterton. Collection of Mr. Vicary. One internal cast of ventral valve. Material not sufficient. (P. 338.)

7, 8. *Spiriferina octoplicata*, Sow. Budleigh-Salterton. Collections of Mr. Vicary and the Rev. H. H. Winwood. (P. 340.)

9—14. *Spirifer Verneuilii*, Murch. = *disjunctus*, Phillips. Perfect specimens and internal casts. Budleigh-Salterton. Collections of Messrs. Vicary, Winwood, and Linford. 14. Albert Memorial Museum, Exeter. (P. 339.)

15—18. *Spirifera speciosa*, Schlothem. Budleigh-Salterton. Collections of Messrs. Vicary and Winwood. (P. 340.)

19. *Rhynchonella Winwoodiana*, Dav. Budleigh-Salterton. Collection of Rev. H. H. Winwood. (P. 340.)

20. *Orthis Hamoni*, Rouault. Found at Budleigh-Salterton in the same pebble with *Rh. Winwoodiana*. Same collection. (P. 344.)

21. *Rhynchonella* ? perhaps *Rh. inaurita ?* Budleigh-Salterton. Museum of Practical Geology. Incomplete specimens. (P. 341).

22—25. „ *elliptica*, Schnur ? 22. Collection of Rev. H. H. Winwood. 23. Internal cast enlarged. Woodwardian Museum, Cambridge. Budleigh-Salterton. (P. 342.)

26—29. „ *Thebaulti*, Rouault. 26, 27. Collection of Mr. Vicary. 28, 29. Museum of Practical Geology. (P. 342.)

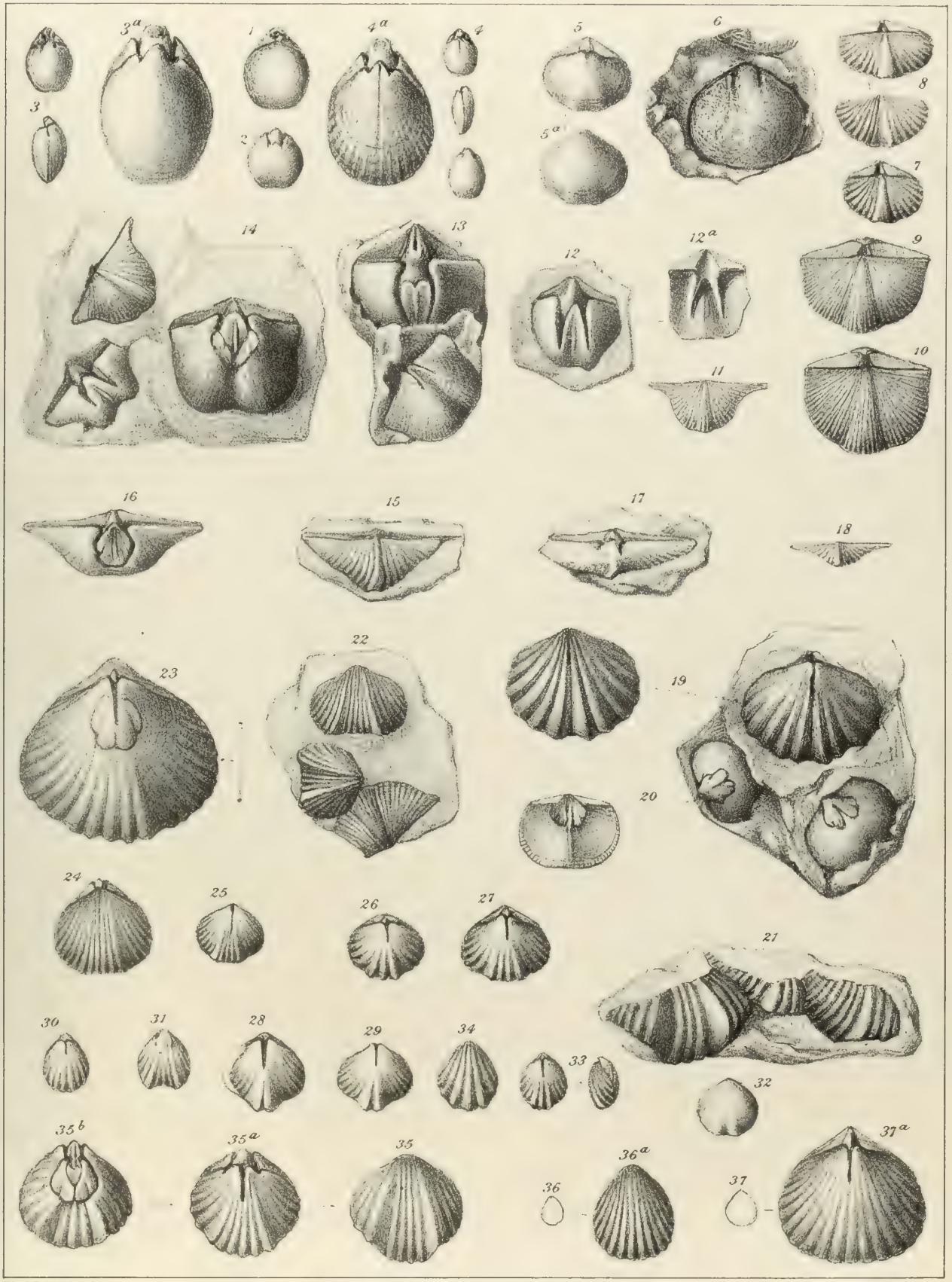
30, 31. „ *Vicaryi*, Dav. Budleigh-Salterton. Collection of Mr. Vicary. (P. 343.)

32. „ ? Dav. Budleigh-Salterton. Museum of Practical Geology. One valve only. Distinct from other species. (P. 344.)

33, 34. „ *Valpyana*, Dav. Budleigh-Salterton. Collection of Mr. Vicary. (P. 343.)

35. „ *inaurita*, Sandb. ? Budleigh-Salterton. (P. 341.)

36, 37. „ *ovalis*, Dav. Budleigh-Salterton. Collection of Mr. Vicary. (P. 344.)



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SUPPLEMENT, PLATE XXXIX.

DEVONIAN.

FIG.

1. *Orthis? hipparionyx?* Portion of the internal cast of a ventral valve. Budleigh-Salterton. Museum of Practical Geology. (P. 347.)

1. *Strophomena*, sp. *a*. Exterior; *b*. Internal cast of dorsal valve. 1 and 1 *a*, *b*. On same pebble. (P. 350.)

2. „ ? sp. Not complete enough for identification. 2 *a*. Enlarged. Budleigh-Salterton. Figure for reference. (P. 351.)

3. *Streptorhynchus crenistria*, Phillips. A fragment of exterior. Budleigh-Salterton. Collection of Mr. Vicary. (P. 351.)

4. *Strophomena Budleighensis*, Dav. 4. Internal cast of ventral valve, nat. size. 4 *a*. Same cast enlarged. 4 *b*. Interior of valve taken in gutta-percha from internal cast and enlarged. Budleigh-Salterton. Collection of Mr. Vicary. (P. 349.)

5—7. „ *Edgelliana*, Dav. 5, 6. Exterior, nat. size. 7. Internal cast of dorsal valve. 7 *a*. Interior of valve taken from the cast and enlarged. 7 *a*. Interior of ventral valve, enlarged. Budleigh-Salterton. Collection of Mr. Vicary. (P. 349.)

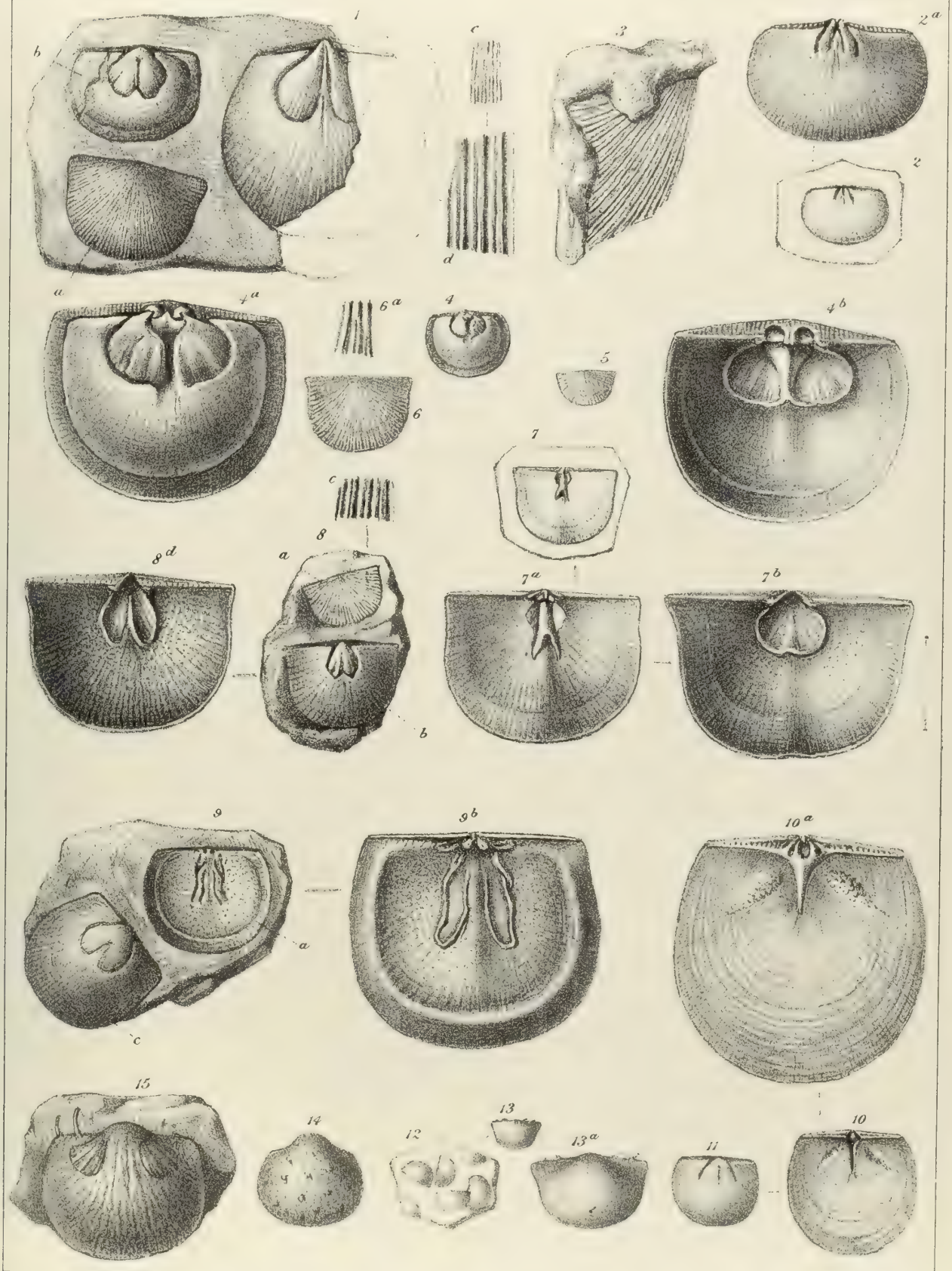
8. „ *Vicaryi*, Dav. 8 *a*. Exterior. 8 *b*. Internal cast of ventral valve. 8 *d*. Interior of ventral valve, enlarged. Budleigh-Salterton. Collection of Mr. Vicary. (P. 348.)

9. „ *Rouaulti*, Dav. 9 *a*. Internal cast of the interior of dorsal valve; *c*. Internal cast of ventral valve, nat. size. 9 *b*. Interior of dorsal valve, much enlarged. Budleigh-Salterton. Collection of Mr. Vicary. (P. 348.)

10, 11. „ *Etheridgii*, Dav. 10. Internal cast of dorsal valve. 10 *a*. Interior of dorsal valve, much enlarged. 11. Internal cast of ventral valve. Budleigh-Salterton. Collection of Mr. Vicary. (P. 350.)

12, 13. *Chonetes*, sp. 12. A group of small specimens. 13. Internal cast. 13 *a*. Enlarged. Budleigh-Salterton. Collections of Mr. Vicary and Major Wyatt-Edgell. (P. 352.)

14, 15. *Productus Vicaryi*, Salter, sp. 14. Exterior showing spines. 15. Internal cast of ventral valve (*Leptæna Vicaryi*, Salter). Budleigh-Salterton. Collection of Mr. Vicary. (P. 351.)



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BUDLEIGH SALTERTON

SUPPLEMENT, PLATE XL.

DEVONIAN.

FIG.

1—8. *Orthis Monnieri,* Rouault. 1 *a*. Exterior of ventral valve, enlarged. 1 *b*. Interior of ventral valve; and 2, 3, exterior of dorsal and ventral valves, enlarged. 4 *a*. Internal cast of dorsal valve. 4 *b*. Interior of same valve, enlarged. Coll. of Rev. H. Winwood. 5. Exterior of young specimens. Museum of Practical Geology. 6. Internal cast of ventral valve. 6 *a*. Interior of valve, enlarged. Collection of Mr. Vicary. 7. Profile view, enlarged. 8. Internal cast of both valves, nat. size. All from Budleigh-Salterton. (P. 345.)

9, 10. *Crania transversa,* Dav. Budleigh-Salterton. Museum of Mr. Vicary. (P. 352.)

11—13. *Discina Vicaryi,* Dav. 11, 12. Budleigh-Salterton. 13. Chisel Bank. All from Collection of Mr. Vicary. (P. 353.)

14, 15. „ *incerta,* Dav. Budleigh-Salterton. Collection of Mr. Vicary. (P. 353.)

SILURIAN.

16—20. *Lingula Lesueuri,* Rouault. 16. Specimen with peduncle. Collection of Mr. Vicary. 17. Portion of a large specimen. Woodwardian Museum, Cambridge. 18. A very elongated example. Collection of Rev. H. Winwood. All Budleigh-Salterton. 19. From the Drift, Ladypool Lane, near Birmingham. Woodwardian Museum, Cambridge. 20. A group of small specimens. Budleigh-Salterton. Albert Memorial Museum, Exeter. (P. 361.)

21. „ *Hawkei,* Rouault. Showing muscular impressions, from a quartzite pebble. Drift, Woodbury Common. Albert Memorial Museum, Exeter. (P. 363.)

22, 23. *Dinobolus Brimonti,* Rouault, sp. Budleigh-Salterton. (P. 365.)

24. *Lingula ? Salteri,* Dav. Budleigh-Salterton. (P. 364.)

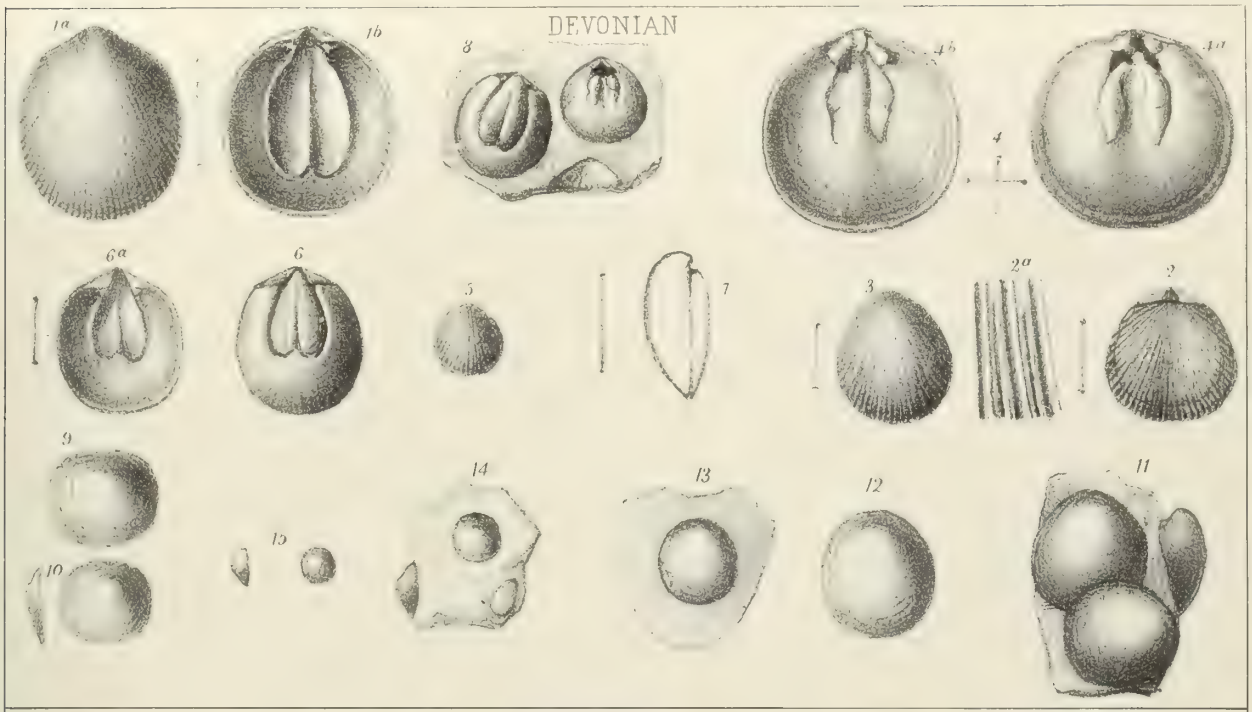
25, 26. „ *Morierei,* Tromelin. Budleigh-Salterton. Collection of Mr. Vicary. 26. Shows the muscular impressions. (P. 354.)

27. „ ? Referred by Mr. Etheridge to *L. crumena,* but may be a malformation of *L. Hawkei.* Budleigh-Salterton. Museum of Practical Geology. (P. 363.)

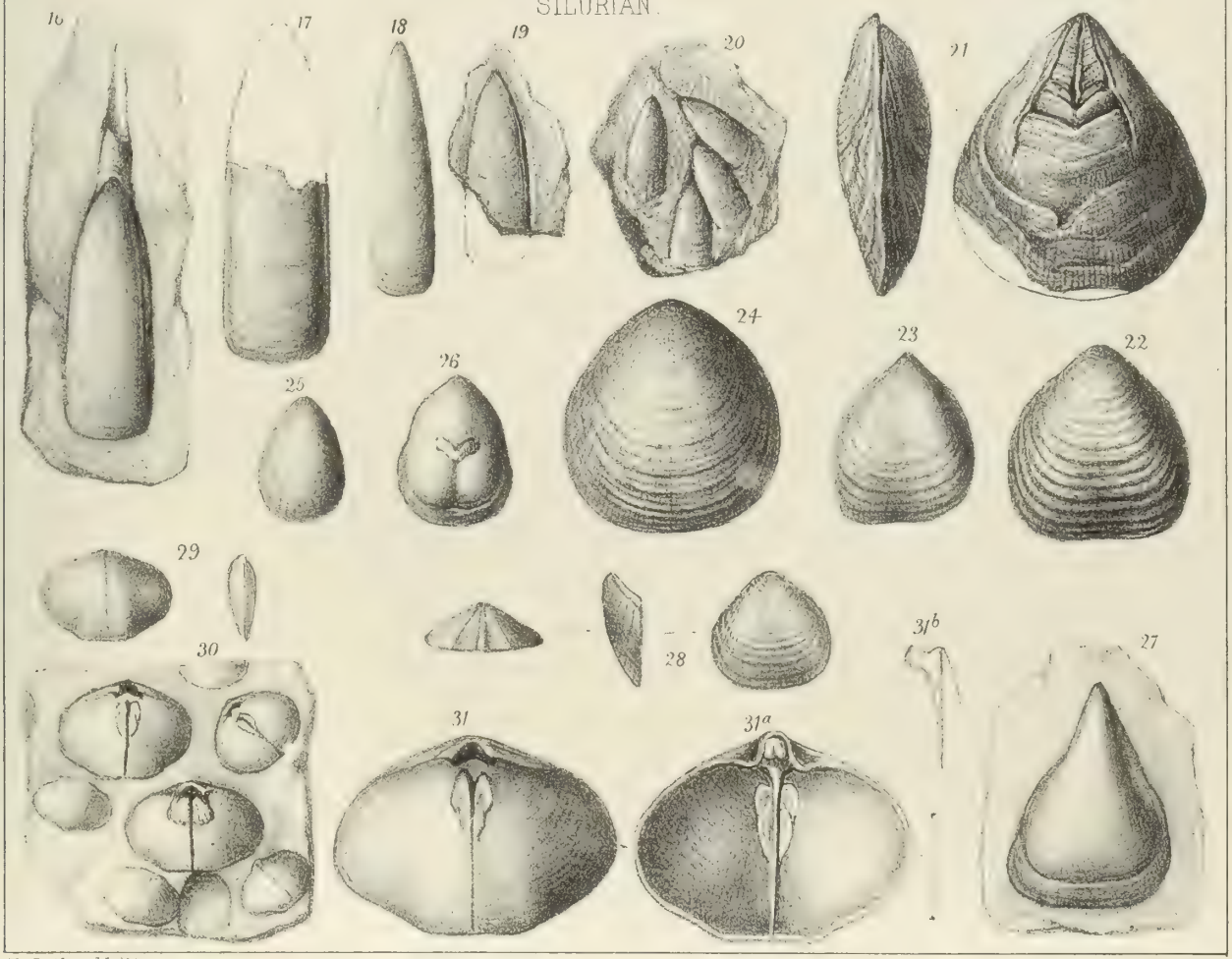
28. ? Species not determinable. Budleigh-Salterton. Collection of Mr. Vicary.

29—31. *Nucleospira Vicaryi,* Dav. 29. Exterior of shell; internal casts of both valves, nat. size. 31. Internal calyx of ventral valve. 31 *a*. Interior of same valve. 31 *b*. Cardinal process seen in profile. Budleigh-Salterton. Collection of Mr. Vicary. (P. 355.)

DEVONIAN



SILURIAN.



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BUDLEIGH-SALTERTON.

SUPPLEMENT, PLATE XLI.

SILURIAN.

FIG.

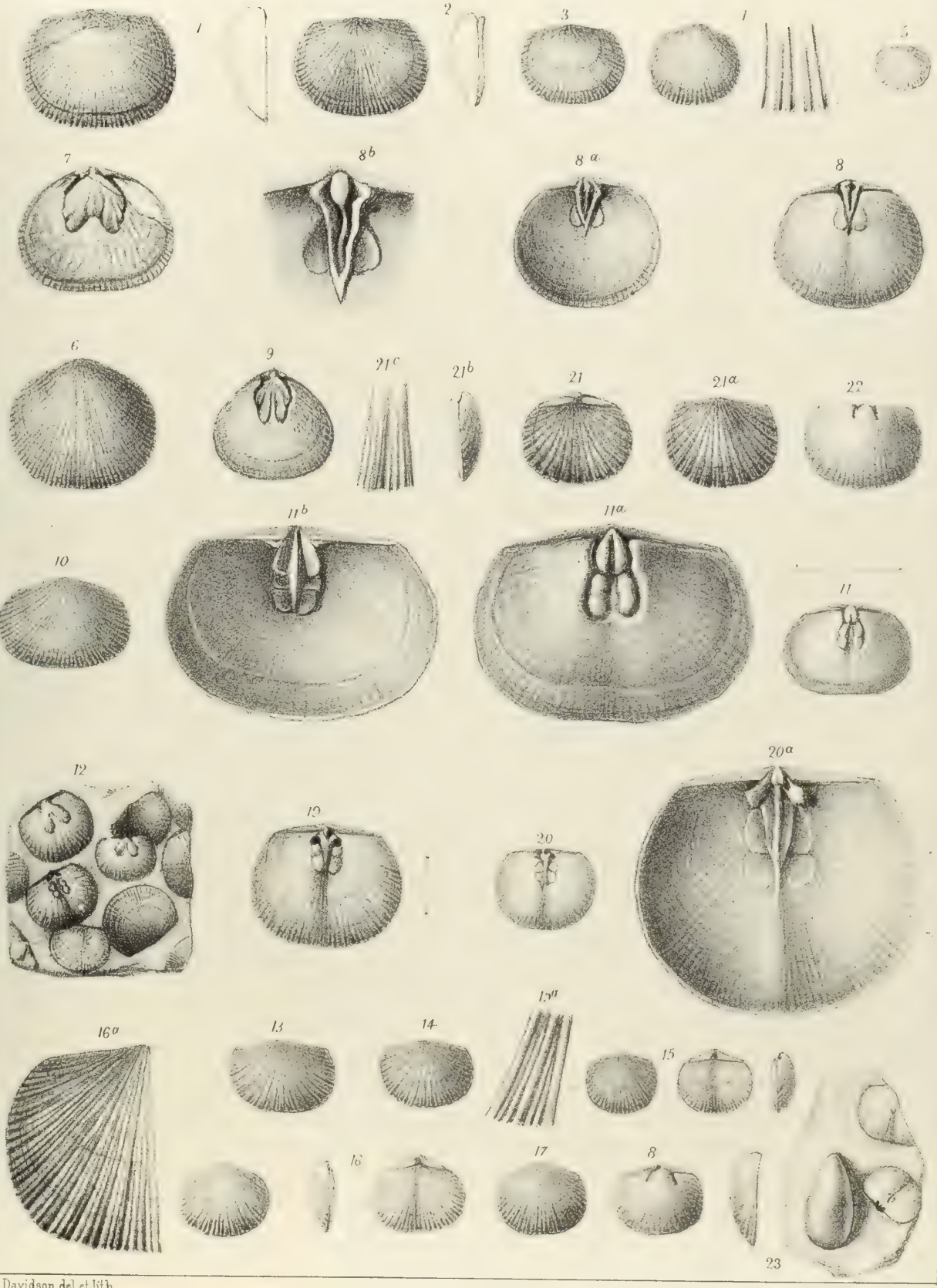
1—9. *Orthis Berthosi*, var. *erratica*, Dav. Interior of both valves natural size. Coll. Rev. H. Winwood and Mr. Vicary. 4. From Museum of Practical Geology. 7. Internal cast of ventral valve. 8. Internal cast of dorsal valve. 8 *a*. Interior of dorsal valve. 8 *b*. Portion of the same enlarged. 9. Natural size of ventral valve. 7, 8, 9. Museum of Practical Geology. All from Budleigh-Salterton. (P. 356.)

10, 11. „ *pulvinata*, Salter, sp. 10. Exterior. 11. Interior of dorsal valve after Mr. Salter's figure in Quarterly Journal Geol. Soc. 11 *a*. Internal cast enlarged; interior of same valves enlarged. Budleigh-Salterton. Collection of Mr. Vicary. (P. 357.)

12—20. „ *Budleighensis*, Dav. 12. Group of internal casts and external impressions; nat. size. 13—17. Different forms, dorsal and ventral valves, of same species, nat. size, from the Museum of Practical Geology and the collections of the Rev. H. Winwood and Mr. Vicary. 16 *a*. Exterior much enlarged. 18. Internal cast of ventral valve. 20. Internal cast of dorsal valve; interior of same valve much enlarged. Woodwardian Museum, Cambridge. All from Budleigh-Salterton. (P. 358.)

21, 22. „ *Valpyana*, Dav. 21, 21 *a*. Exterior of both valves. 22. Internal cast of ventral valve. Budleigh-Salterton. Collection of Mr. Vicary. (P. 361.)

23. *Terebratula?* sp. Budleigh-Salterton. Collection of Mr. Vicary. (P. 354.)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20a
16a
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17a
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SUPPLEMENT, PLATE XLII.

CORNISH LOWER SILURIAN.

FIG.

1, 2. *Strophomena grandis*, Sow. In a light grey quartzite, Carn Gorran, Cornwall. 2. A restored figure from an impression of exterior of ventral valve taken in gutta percha. (P. 329.)

3. ,, ,, Portion of exterior of dorsal valve. (P. 329.)

4. ,, ,, Longitudinal section of both valves. (P. 329.)

5. ,, ,, Fragment of internal cast of ventral valve. (P. 329.)

6. ,, ,, Fragment of internal cast of dorsal valve. (P. 329.)

Figs. 1 to 6 from specimens in the Penzance Museum.

7, 7 *a*. *Orthis calligramma*, var. Distorted external impressions. Carn, Gorran Haven. Penzance Museum. (P. 329.)

8—10. ,, ,, 8. Internal cast of ventral valve. 9. External surface of shell enlarged. 10. Interior of ventral valve. Gorran Haven. Museum of the School of Mines, London. (P. 329.)

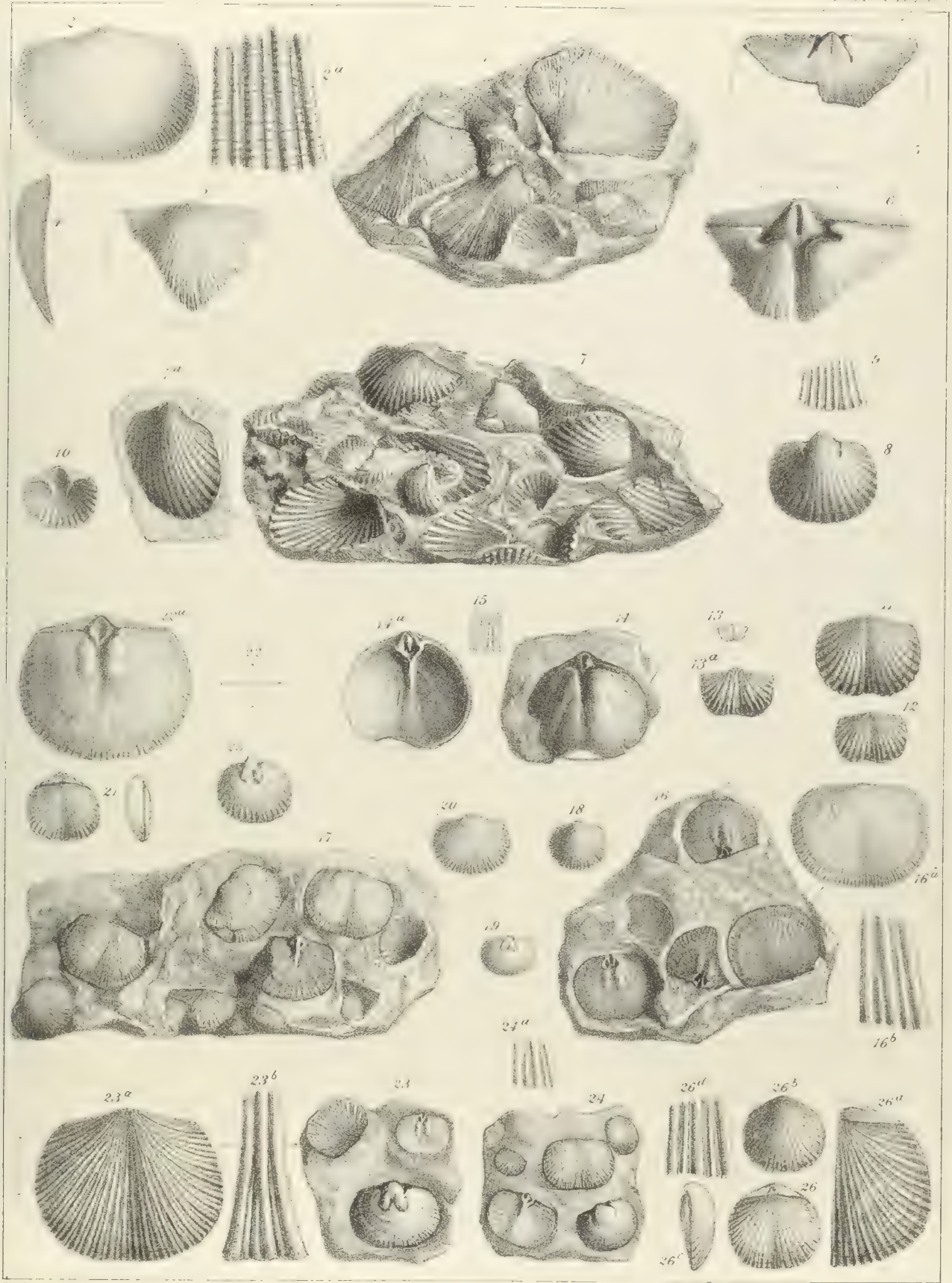
11, 12. ,, *scotica*? M'Coy, sp. From impressions of dorsal valve in dark grey limestone. Gorran Haven. Penzance Museum. (P. 329.)

13. ,, sp.? Carn of Gorran Haven. Mus. Geol. Soc. Ed.

14, 15. ,, *Berthoisi*, var. *cornubiensis*, Tromelin. This is probably the shell referred to by Prof. M'Coy to his *O. turgida*. Caerhayes. 14. Internal cast, Truro Museum. 14 *a*. Interior of dorsal valve taken in gutta percha from internal cast, fig. 14. 15. Fragment showing exterior sculpture. (P. 329.)

16—25. ,, *Budleighensis*. 16, 17. Large very flat dorsal valves in a light grey quartzite, Carn near Gorran Haven, and presented by Mr. Peach to the Edinburgh Geol. Society. 17. The same in a yellowish-grey quartzite in the Penzance Museum. These are probably the specimens referred by M'Coy to his *Orthis retrorsistria*, and to some very flat forms of which it bears much resemblance. 16 *a*, *b*. Enlarged. 18, 20. Ventral valve. Gorran Haven and Gerran Bay. Penzance Museum. 19, 25. Internal casts of ventral valve. 21. Dorsal valve. Gerran Bay. 23, 24. Dorsa valve and internal casts of dorsal and ventral valves. 23 *a*, *b*. Enlarged. Gorran Haven. Museum of School of Mines, London. (Pp. 329, 358.)

26. ,, *testudinaria*, Dalman type. Specimen from Borenshult in Ostrogothia, Stockholm, Sweden, and lent by State Museum. Figured here for comparison with British specimens. (P. 359.)



Thos Davidson del et lith.

CORNISH LOWER SILURIAN BRACHIOPODA

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1881.

LONDON:

MDCCCLXXXI.

A MONOGRAPH

OF THE

BRITISH FOSSIL TRIGONIÆ.

BY

JOHN LYCETT, L.R.C.P.E., &c.

SUPPLEMENT.

Pages 1—3.

LONDON:

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1881.

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SUPPLEMENT TO THE MONOGRAPH

OF THE

BRITISH FOSSIL TRIGONIÆ.

The discovery of two species of *Trigonia* in the Lower Lias of Oviedo, Northern Spain, is an important fact in Palæontology, as it carries back the genus in Geological time almost to the Trias, and therefore nearly to the position of its allied genus and precursor, *Myophoria*. Previously, the oldest recorded species of *Trigonia* of which we have any certain knowledge was the *Trigonia Lingonensis*, Dum., obtained in the upper portion of the Middle Lias of France and England.[1] The Spanish *Trigoniæ* now described were obtained by Dr. Charles Barrois, of the Faculté des Sciences, Lille, and are stated by him to occur on the border of the Liassic basin of Oviedo, overlying Trias. I have previously, at page 211 of my 'Monograph on Trigoniæ,' mentioned my obligations to Dr. Barrois for his important contributions of Belgian Trigoniæ to that work, and have now again to express my thanks and recognition of the high value of his present contribution. Dr. Barrois refers these *Trigoniæ* to the *Angulatus zone* of the Lower Lias, and mentions that he has transferred his Jurassic fossils to his friend, Mons. A. Six, of Lille (Secretary to the Northern Geological Society), who is actively engaged in the study of the Jurassic rocks of Eastern France. A subsequent communication obligingly contributed by the latter gentleman, contains much additional information respecting these Spanish *Trigoniæ*, and informs me that the fossils associated with them are in bad preservation, that some of them are new, that there are no Cephalopoda with them, and that he has ascertained the following species of Lamellibranchiata, *Cardinia concinna*, Sow., *Astarte detrita*, Goldf., *Protocardia Phillipiana*, Dunker., *Protocardia truncata*, Sow., also a gigantic *Gervillia*, upwards of eleven centimètres in length. These fossils he assigns to the Etage Hettangien or Infra Lias of Turquem and Pictte. The *Trigoniæ* were associated with the gigantic *Gervillia*, the position of which he believes to be the upper portion of the *Angulatus zone;* carbonaceous masses also occur. The lithological aspect of the *Trigoniæ* resembles that of the fossils generally from the Lower Lias shale; they are all separated valves. These are the oldest examples of *Trigoniæ* of which we have any certain knowledge.

[1] 'British Trigoniæ,' p. 98, also pp. 219.

Trigonia Oviedensis, *Lycett.* Sp. nov. Woodcuts, figs. 1 and 2, nat. size.

Shell ovately oblong, somewhat Unio-like, moderately convex anteally and mesially, more depressed posteriorly; umbones not very large or prominent, but pointed, and situated within the anterior third of the valve; the ornamented or costated portion of the surface occupies about three-fourths of the valve; the costæ are very numerous, very closely arranged, not prominent, for the most part closely and imperfectly tuberculated; the tubercles are depressed and often obscure; the general direction of the rows is horizontal, those occupying the first four lines in height adjacent to the apex are linear and nearly smooth; their arrangement is so close that about twenty-five may be counted; the costæ of the other and greater portion of the valve, about twenty-five in number, are tuberculated and horizontal; the rows become somewhat more prominent at

Fig. 1. Fig. 2.

Trigonia Oviedensis, from Spain.

their posteal extremities, where they terminate abruptly at the smooth ante-carinal space; they are sometimes undulated, but all have a general horizontal direction. The smaller or smooth portion of the shell, represents a narrow ante-carinal space, a narrow smooth area with obscure bounding carinæ, and a narrow, lengthened escutcheon; the latter is about half the length of the entire valve; the area has also a slightly defined mesial furrow. The specimens contributed by Dr. Barrois differ among themselves in the prominence of the subtuberculated costæ, but the general figure of the shell is nearly alike though essentially different from its allied congeners of the *glabræ*, from which it it is separated by the ovately oblong figure, by the small umbones and by their anteal position.

In the character of the ornamentation in *T. Oviedensis* there is a remarkable fact, inasmuch as it is nearly allied to a species of the same section (*Glabræ*) placed almost at the opposite extremity of the Jurassic species, viz. the *T. tenuitexta*, Lyc., of the Portland formation;[1] but in the general figure the two species are strikingly different; in fact the shape is the feature by which *T. Oviedensis* is most conspicuously distinguished, and which at once separates it from the Portlandian *Glabræ*.

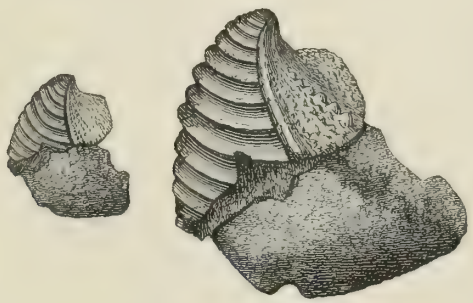
[1] Monograph, p. 90.

Dimensions.—Length of the specimen in Fig. 1 21 lines; height 16 lines; convexity of a single valve 5 lines. Fig. 2, a more imperfect specimen, has the ornamentation more strongly defined. A third example retains little more than the ornamented portion of the surface; a fourth specimen is smaller and nearly entire in outline, but retains little more of the surface than the irregular lines of growth.

TRIGONIA INFRA-COSTATA, *Lycett.* Sp. nov., figs. 3 and 4. (Fig. 4 enlarged one diameter.)

Of this small species of the *Costatæ,* I have only a single imperfect example, fortunately the portion preserved possesses all the features necessary to characterise the species; it is remarkable for the unusual prominence of the ornamentation upon the escutcheon and the area, and more especially for the great breadth of the escutcheon; the costæ (of which about seventeen are preserved) are narrow, very prominent, and

FIG. 3. FIG. 4.



Trigonia infra-costata, from Spain.

much marked transversely by decussating lines of growth which indent their surfaces, rendering them slightly nodulous; their posteal extremities are well separated from the marginal carina, which is large, and has its tubercles unusually prominent; the inner and median carinæ are well-defined; there are also some small inter-carinal costellæ. The escutcheon is very wide and flattened, its large irregular tubercles give to it a roughened nodose aspect. The umbones are narrow, prominent, and recurved. The anterior side is somewhat compressed and sinuated. Apparently, the shell if perfect would have more than twice the height of the portion preserved. It was associated with *T. Oviedensis,* and appears to be more rare than that species.

By referring to the comparison of the genus *Myophoria* with the *Costatæ* at p. 215 of this Monograph, the above description of the present species will show that both by its figure and surface ornaments it is clearly separated from *Myophoria,* and that it possesses all the attributes of the *Trigoniæ costatæ,* even more strongly developed than is usual with that section. The curvature of the umbones is more especially well marked, and would alone suffice to establish its generic identity.

THE

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MDCCCLXXXI.

MONOGRAPH

ON THE

LIAS AMMONITES

OF

THE BRITISH ISLANDS.

BY

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VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE; THE SOCIETY OF NATURAL SCIENCES OF NEUCHÂTEL; VICE-PRESIDENT OF THE COTTESWOLD NATURALISTS' FIELD CLUB; CONSULTING SURGEON TO THE CHELTENHAM HOSPITAL; AND MEDICAL OFFICER OF HEALTH TO THE URBAN SANITARY DISTRICTS OF CHELTENHAM, CHARLTON KINGS, AND LECKHAMPTON.

PART FOURTH—DESCRIPTION OF SPECIES.

PAGES 265—328; PLATES XXII A, XXII B, XLI—XLVIII.

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The sub-kingdom Mollusca contains a vast variety of forms, representing many degrees of perfection in the animal series. One section has no head, and another possesses that important division of the body. The headless section comprises the Molluscoida and the Acephala; the first consisting of the classes *Polyzoa, Tunicata, Brachiopoda;* the second of the *Lamellibranchiata.* The Cephalophora, possessing a head, includes the classes *Gasteropoda, Pteropoda,* and *Cephalopoda.*

The *Polyzoa* are minute animals in cells, forming colonies of chitinous or calcareous polyzoaria; each zoïd having a tentaculated mouth, a bent alimentary canal, and a nerve ganglion, in a double-walled sac. The embryo, leaving the egg, is locomotive for a time, and ultimately gives origin to the polypides by gemmation.

The *Tunicata* are soft, marine, acephalous Mollusks, with one exception, destitute of a calcareous shell, breathing by reticulate branchiæ which line an internal sac, and having the body enveloped in an elastic tunic, more or less dense, furnished with at least two apertures. Some of the more simple forms are organically united together into social assemblages; and in one group, the *Salpæ,* there is an alternation of generations, solitary and colonial forms, succeeding each other in a cycle, as was long ago described by J. C. Savigny, Chamisso, and Edwards. Many of this group are likewise highly phosphorescent, the *Pyrosoma,* a compound form inhabiting the Atlantic Ocean, being one of the most vividly luminous animals met with in the seas. The simple forms, constituting the order *Ascidiada,* possess a higher organisation; their body is enclosed in a cartilaginous tunic lined with a muscular mantle, and having the respiratory aperture surrounded by sensitive filaments, as seen in *Cynthia* and *Phallusia.* The morphology of this group has been carefully examined by Krohn, Giard, Lacaze-Duthiers, Kowalevzky; and the homology of the organs of the *Tunicata,* compared with those of the *Polyzoa,* has been studied by Allman.

The *Brachiopoda* are fixed bivalved animals, attached by a pedicle which passes through a hole in the beak of the larger or ventral valve, and anchors it to some submarine body; the smaller or dorsal valve, always free and imperforate, supports on its inner surface a delicate shelly loop or spiral tube, for the attachment of the peculiar organs from which the name of the class is derived; the valves are without a hinge-ligament, and are joined by horny matter, as in the duck-bill shells, *Lingula,* or by tooth-like hinges as in the lamp-shells, *Terebratula.* The mantle is a highly vascular respiratory organ, and there are usually three hearts for carrying on the circulation of the blood, the principal organ lying on the stomach, and the two accessory pumps on the mantle wall. The larvæ of the *Brachiopoda* are freely locomotive, and possess eyes and ear-sacs, but these organs disappear in the fixed adult state, in which the ciliated head-lobe of the embryo becomes converted into the bases of the arms, which are supported on simple shelly loops, or on complicated spiral tubes armed with processes or recurved spines. This class, which played so important a part in the Silurian, Devonian, and Carboniferous seas, and to a less extent in those of the Jurassic and Cretaceous periods, has only a few representatives

now living, and some of these have been carefully studied in relation to their structure and morphology by Owen, Huxley, Hancock, and Davidson, in England, and by Vogt, Fr. Müller, Lacaze-Duthiers, and Suess on the Continent, and by E. S. Morse in America.

The *Lamellibranchiata* are well known to us as Oysters, Mussels, Cockles, and other bivalve shells; they have a two-lobed mantle, under whose folds four lamellæ, or gills for respiration, are concealed, and the circulation is carried on by a heart. The shell consists of, with few exceptions, two valves, which correspond to the right and left sides of the body, the dorsal region being placed under the hinge; from the beak or umbo of each valve of the shell numerous concentric lines of growth running parallel with the margin can be traced; the inner differs from the outer surface by often exhibiting a mother-of-pearl lustre, the cause of difference being seen on examining with a microscope transparent sections of the shell. The development of this class has been carefully studied by Lovèn, Lacaze-Duthiers, and others, from whose observations it appears that important changes take place in the evolution of the embryo, and during the subsequent growth of the Mollusk.

The Cephalophora, or head-bearing Mollusks, comprise the *Gasteropoda*, *Pteropoda*, and *Cephalopoda*.

The Gasteropoda have a body with a large muscular foot extended under the abdomen, adapted for creeping, and a head supporting tentacula and simple eyes. The marine forms breathe by branchiæ, and the lacustrine and terrestrial genera by a pulmonary sac. The body is in general covered with a solid unilocular shell; some are naked, and others have an internal dorsal or branchial shield; the morphology of these animals has formed the subject of special studies for many observers, who have discovered the important changes that take place in this class in the different genera that formed the special objects of their investigations; these belong, however, to a treatise on Embryology, and are too numerous and complicated to be summarised here. The memoirs by Fol, Bobretzky, Gegenbaur, Lovèn, Agassiz, and Lankester, abound with important details regarding the evolution of *Gasteropoda*.

The *Pteropoda* have the body organised for swimming, the mouth closed above, and the branchiæ external; the shell when present is thin, unilocular, and generally inoperculate; these small, soft, floating Mollusks are entirely marine, and swim by the contractions of two lateral musculo-cutaneous fins which support the branchiæ. There appears to be a very close agreement amongst Gastropods and Pteropods in the general character of their larvæ, and the changes they pass through in subsequent stages of growth.

The *Cephalopoda* form the highest class, and their general structure has already been described in the systematic part of this work, where it was shown that the only existing representatives of the order *Tetrabranchiata* are the different varieties of *Nautilus pompilius* found in southern seas. The family to which this genus belongs is one of the oldest, as it can be traced through all the fossiliferous rocks down to those of Cambrian age. In the Silurian rocks we find closely allied forms, which differ from *Nautilus* in the degree of curvature their shell-cone assumes, as in *Lituites, Gyroceras, Trochoceras;* or straightness of

shell, as in *Orthoceras, Gomphoceras;* and in the position, structure, and mode of calcification of the siphuncle, as in *Actinoceras, Huronia, Endoceras.* In the Devonian and Carboniferous rocks the *Ammonoida* appear as *Goniatites*, with the edges of their septa forming angular, zigzag, transverse lines, marking the lobes and saddles; in the Muschelkalk as *Ceratites*, having undulating septa with denticulate borders. In the Triassic, Jurassic, and Cretaceous strata the lobes and saddles become very complicated, and the shells assume a vast variety of forms, being straight, bent, curved, turbinate, or discoidal, as seen in the various groups and genera of the *Ammonitidæ.* The morphology of the Cephalopods has been admirably described by Kölliker, and illustrated with beautiful figures; and later important observations have been made by Grenacher and Lankester "On the Embryology and Development of the Cephalopoda."

Family.—AEGOCERATIDÆ,[1] *Neumayr*, 1875.

This family includes a considerable number of Ammonite groups, which have widely different forms and affinities, so that it is almost impossible to give a general description of the family which shall be correct and comprehensive at the same time.

The lobes present a great variety of ramified figures, and the suture-line is in general complicated; the siphonal lobe is large, and the principal lateral and secondary laterals attain considerable dimensions.

The siphonal area is in general round and well developed; in some there is a keel with lateral channels more or less deeply grooved; in others the shell is flattened and discoidal with a wide open umbilicus; or it is round, and inflated, with highly involute whorls, and a small umbilicus sometimes nearly occulted by the last.

In the presence of so much diversity in form and structure this family is subdivided into three sections:

I. Aegoceratites.—*Arietites, Aegoceras.*

II. Harpoceratites.—*Harpoceras, Oppelia, Haploceras.*

III. Stephanoceratites.—*Stephanoceras, Cosmoceras, Ancyloceras, Baculina, Simoceras, Perisphinctes, Olcostephanus, Scaphites, Hoplites, Acanthoceras, Stoliczkaia; Crioceras, Heteroceras, Peltoceras, Aspidoceras.*

Section I.—Aegoceratites.

Genus I.—Arietites, *Waagen*, 1869.

Family—Arietes, *von Buch.* Ueber die Ammoniten, p. 9, pl. iii, fig. 1, 1832.
— *d'Orbigny.* Paléont. franç., Ter. Crét., tom. i, p. 405, 1841.
— *Pictet.* Traité de Paléontologie, 2 ed., tom. ii, p. 671, 1854.
Arieten, *Quenstedt.* Handbuch, 2nd ed., p. 422, 1867.

[1] See pages 238 and 246 of this Monograph.

Genus—Arnicoceras, *Hyatt*. Fossil Cephalopoda, Bull. Mus. Camb., U.S.A., p. 73, 1868.
Ophioceras, *Hyatt*, ibid., p. 75; Discoceras, *Hyatt*, ibid., p. 76.
Coroniceras, *Hyatt*, ibid., p. 77; Asteroceras, *Hyatt*, ibid., p. 79.
Family—Discoceratidæ, *Hyatt*, ibid., p. 73.
Genus—Arietites, *Waagen*. Formenreihe des *A. subradiatus*, Beneckes geog. pal. Beitr., Band ii, p. 247, 1869, and Palæont., Band xvii, p. 198, 1870.
— *Neumayr*. Zeitschrift Deut. geolog. Gesell., Band xxvii, p. 906, 1875.

Shell discoidal, with a wide umbilicus. The sides of the whorls covered with straight simple ribs, which often have tubercles developed on them near the ventral angle, as seen in *Arietites rotiformis*, fig. 182, and still better shown in Pl. IX, figs. 1, 2. In all the species the keel is large and prominent, and accompanied by two lateral channels (fig. 184). The mouth-border is simple, scooped away on the sides, and furnished with a long, projecting ventral process. The body-chamber is from one to one whorl and a quarter in length.

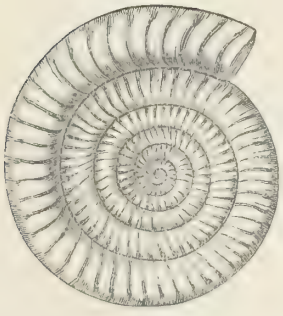


Fig. 182.—*Arietites rotiformis*, Sow. Side.

Fig. 183.—*Arietites obtusus*, Sow. Side.

Fig. 184.—*Arietites obtusus*, Sow. Front.

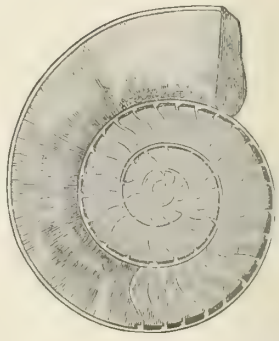


Fig. 185.—Section of *Arietites obtusus*, Sow.

The lobes are very characteristic (see *Arietites bisulcatus*, Bruguière, Plate III, fig. 3). The siphonal lobe is nearly as deep as it is broad, and the point of its adhesion to the siphuncle is nearly in the middle of its depth. The principal lateral lobe does not reach to half its depth, and is sometimes as broad as it is deep. The lateral saddle rises above all the others and stands upon the ground of the principal lateral lobe, in general double the height of the siphonal saddle. The lower lateral lobe is likewise much broader than deep, and the columellar saddle is so small that it does not reach to half the height or breadth of the lateral saddle and ends in two branches.

The genus *Arietites* is readily distinguished from the other genera of the Aegoceratidæ. Its closest affinities are with *Harpoceras* and *Amaltheus*. It differs from *Harpoceras* in the absence of bent, sickle-shaped ribs, the short body-chamber, the different figuring of the lobe-line, and the want of a bivalved calcareous Aptychus. It differs from *Amaltheus* in possessing a long body-chamber. In *Amaltheus* it is short, from two-thirds to one-half of a whorl in length. The mouth-border is likewise simple, the ventral portion ending in a long projecting process. The lobe-line is moreover

extremely ramified in *Amaltheus*, and the siphonal lobe is shorter than the principal lateral lobe, which is mostly broad and wedge-shaped. These characters form a good diagnosis for this genus.

The *Anaptychus* is, thin, horny and undivided; in some species it is bell-shaped. I have found Anaptychi in the body-chamber of *Arietites stellaris*, Sow., and of *Arietites semicostatus*, Young and Bird, where it exhibited these characters.

The distribution of this genus is limited to the Lower Lias; and its various species characterise the different zones of life in which they are found, a fact which was well known to, and clearly pointed out by, Leopold von Buch, in his classical memoir, "Ueber die Ammoniten in den älteren Gebirgs-Schichten" (1830).

ARIETITES BUCKLANDI, *Sowerby*. Pl. I, figs. 1—3.

AMMONIS CORNU,	*Lister*. Animal. Angliæ, tab. vi, fig. 1, p. 207, 1678.
— — STRIATUM STRIIS INTEGRIS (pars),	*Lang*. Historia Lap. fig. Helvetiæ, tab. xxiv, fig. 1, p. 95, 1708.
AMMONITES BISULCATA,	*Bruguière*. Encyclopédie Méthodique, tom. i, p. 39, 1792.
— BUCKLANDI,	*Sowerby*. Min. Conch., vol. ii, p. 69, tab. cxxx, 1816.
— ARIETES,	*Schlotheim*. Petrefactenkunde, p. 62, No. 4, 1820.
PLANITES BISULCATUS,	*de Haan*. Monogr. Ammonit. et Goniatit., p. 91, 1825.
AMMONITES BUCKLANDI,	*von. Buch*. Physik. Abhandl. Akad. Berlin, über Ammoniten, p. 142, tab. iii, fig. 1, 1832 (read 1830).
— —	*Zieten*. Verstein. Württemb., p. 35, tab. xxvii, fig. 1, 1830.
— —	*Deshayes*. Coquilles charac. des Terrains, p. 240, pl. x, fig. 2, 1831.
— —	*Bronn*. Lethaea Geognostica, i, p. 421, tab. 22, fig. 1, 1833.
— —	*Mandelsloh*. Constit. Geogn. Alp. Württemberg., fig. 33, 1835.
— —	*Römer*. Norddeutsch. Oolithen-Gebirg., p. 182, 1836.
— —	*Buckland*. Geol. and Min., ii, p. 59, tab. 37, fig. 6, 1836.
— —	*Quenstedt*. Flözgebirge Württemberg., p. 131, 1843.
— —	*Simpson*. Monogr. of Lias Ammonites, Yorkshire, p. 52, 1843.
— —	*Quenstedt*. Petref. Deutsch. Cephalopoden, p. 76, 1846.
— —	*Quenstedt*. Handbuch der Petrefactenkunde, p. 354, 1852.
— BISULCATUS	*Chapuis et Dewalque*. Terr. Second. de Luxembourg, p. 42, pl. v, fig. 3, 1853.
— BUCKLANDI,	*Studer*. Geologie der Schweiz, Band ii, p. 234, 1853.
— —	*Simpson*. Monogr. of Yorkshire Fossils, Yorkshire, p. 97, 1855.
— —	*Oppel*. Die Juraformation, p. 76, 1856.
— —	*Quenstedt*. Der Jura, p. 67, pl. vii, fig. 3, 1858.
— —	*Dumortier*. Dépots Jurassiques du Bassin du Rhône, tom. ii, p. 19, 1867.
ARIETITES —	*Tate & Blake*. Yorkshire Lias, p. 283, pl. v, fig. 2, 1876.

Diagnosis.—Shell discoidal, depressed; whorls slightly involute; sides convex and largely costated; ribs thick, bent, remote, twenty-four in a whorl; back flat, strongly carinated, with a deep furrow on each side of the keel; aperture quadrato-hemispherical.

Dimensions.—Transverse diameter of figured specimen, 230 millimètres; height of the last whorl at the aperture 65 millimètres; width 75 millimètres; whorls about one fifth involute. Many of the large specimens from Keynsham measure 18 inches in diameter.

Description.—This Ammonite attains a gigantic size, it has a flattened discoidal shell, formed of six or seven slightly involute whorls, having the inner ones largely exposed; their sides are convex, sub-cylindrical, and separated by a deep suture, having strong prominent ribs, from twenty-four to thirty-two in a whorl, which are sharp, distant, simple, arched, and terminate abruptly near the border where they are interrupted; the siphonal area forms a broad flattened arch, and the middle line is occupied by a strong thick keel, bounded on each side by a deep furrow; the aperture is rounded or sub-quadrangular.

The septa are symmetrical, divided on each side into three lobes and three saddles formed of unequal parts. The siphonal lobe is narrow, one third longer, and a little wider than the principal-lateral lobe, and has on each side five nearly equal-sized serrated digitations (Pl. I, fig. 3).

The *siphonal saddle*, one fourth wider than the principal-lateral lobe, is divided into seven leaves of unequal size. The *principal-lateral lobe*, a little longer than wide, has on each side three elongated foliated digitations. The *lateral saddle*, twice the size of the principal lateral lobe, is formed of eight or nine subdivided lobules. The *infero-lateral lobe*, smaller than the principal-lateral, has four external and three internal digitations. The *auxiliary saddle* is small, with five small lobules. The *auxiliary lobe* is small, with three digitations.

Affinities and Differences.—This species was first described by M. Bruguière in the 'Encyclopédie Méthodique,' tom. i, p. 39, under the name *Ammonites bisulcata*. The diagnosis included two forms—(A) *Ammonites Bucklandi*, Sow.; and (B) *Ammonites multicostatus*, Sow.

(A) "*Ammonites costis simplicibus raris, dorso bisulcato carina acuta intermedia.*" Brug.

(B) "*Ammonis cornu spina in ambitu eminente, striis lateralibus ex toto orbem valde extimum trajicentibus.*" Lister.

The variety A had been previously figured by Lang in his 'Historia Lapidum figuratorum Helvetiæ,' p. 95, tab. xxiv, fig. 1, and described as "*Ammonis cornu striatum valde striis integris in spinam inter duos sulcos eminentem abeuntibus.*"

I propose to retain Sowerby's name for var. A, and Bruguière's name, *bisulcata*, for var. B, as the forms are very distinct and readily distinguished from each other. *A. multicostatus*, Sow., will then be a synonym of *A. bisulcatus*, Brug.

Arietites Bucklandi has twenty-four to thirty-two ribs, which gradually disappear on the outer border, without tubercles near the angle of the sulci.

Arietites bisulcatus has a quadrate angular form, with from forty-four to fifty ribs, with a tubercle on each near the angle of the siphonal border, from whence they curve forward into the sulcus.

There is no other form in the Lower Lias for which *Arietites Bucklandi* can be mistaken.

Locality and Stratigraphical Position.—Arietites Bucklandi characterises an important zone of life in the English Lias, the stratigraphical relations of which are best exposed in the magnificent coast section near Lyme Regis. I have collected this Ammonite at Fretherne Cliffs, on the banks of the Severn, and fragments of it from the Lower-Lias Limestones in the counties of Glamorgan, Somerset, Gloucester, Worcester, and Warwick, and from the same formation where it is worked at Scunthorpe in the north-west of Lincolnshire; and also where it is exposed at Redcar, and Robin Hood's Bay, on the Yorkshire Coast. The finest specimens I have obtained were found on the coast near Lyme Regis, and in the Great Western railway cutting, in the Lower Lias, at Salford, near Bath. Several fine specimens are preserved in the collection of the British Museum.

Foreign Distribution.—The two varieties of this Ammonite have a very wide range in space, and form conspicuous leading fossils in the horizon they characterise. In France it has been collected at Saint Rambert, Ain; Paillet, Mont-d'Or, Saint Fortunat près de Lyon, Rhone; Avallon, Yonne; Sémur, Côte-d'Or; Salins, Jura; Pouilly-sous-Charlieu, Loire; Fontenay, Vendée, Moselle.

In North Germany this species has been found at Orsleben and near Harzburg, at Solenhai, near Leibenburg, and Falkenhagen, near Rischenau, and several other localities, by Ewald, Strombeck, and Schlönbach.

In South Germany very fine large specimens of this Ammonite, nearly identical with the large examples found near Bath, are found in Würtemburg, Swabia, and Baden, and are preserved in the Museums of Sémur, Stuttgart, and Tübingen.

In Austria it is found in the north-eastern Alps, associated with other leading fossils appertaining to the same zone. La Spezzia, Tuscany (Pilla).

In Luxembourg this species is collected from the "Grès de Luxembourg."

I beg to refer the reader to the detailed sections I have given of the Bucklandi-beds at Saltford (pp. 36 and 37), and at Broad Ledge on the shore of Lyme Regis (pp. 38 and 39), as the best examples I at present know of the stratigraphical position and relation of this Life-horizon in the British Islands.

In describing this Ammonite Mr. James Sowerby remarks :—"Found in the Blue Lias of Bath and the neighbourhood, measuring from a foot to twenty-one inches or more in diameter, and rather remarkable for having frequently lost the inner whorls; which circumstance, by a sort of friendly pun, has given rise to the name given to it in honour of a meritorious and enlightened geologist, the Rev. W. Buckland, who, having found a large specimen, was induced by his ardour to carry it himself, although of considerable

weight, and, being on horseback, it was not the less inconvenient; but the inner whorls being gone so as to allow his head and shoulder to pass through, he placed it as a French horn is sometimes carried, above one shoulder and under the other, and thus rode with his friendly companions, who amused him by dubbing him an 'Ammon Knight.'"[1]

ARIETITES CONYBEARI, *Sowerby*. Pl. II, figs. 1, 2, 3.

Lister. Animal. Angliæ, p. 206, tab. vi, fig. 2, 1678.
— Synopsis Conchyliorum, tab. 1039, fig. 18; tab. 1041, fig. 20, 1692.
AMMONIS CORNU, STRIATUM, STRIIS INTEGRIS (pars), *Lang*. Hist. Lap. fig. Helv., tab. xxiv, p. 95, 1708.
AMMONITES CONYBEARI, *Sowerby*. Mineral Conchology, vol. ii, p. 70, tab. 131, 1816.
— NATRIX *Schlotheim*. Petrefactenkunde, p. 62, Gotha, 1822.
PLANITES CONYBEARI, *de Haan*. Monogr. Ammon. et Goniat., p. 90, 1825.
AMMONITES — *Phillips*. Geology of the Yorkshire Coast, p. 164, pl. xiii, fig. 5, 1829.
— — *Sedgwick & Murchison*. Trans. Geol. Soc. Lond., 2nd series, vol. iii, p. 312, 1830.
— — *Zieten*. Die Verst. Würt., p. 35, tab. xxvi, fig. 2, 1830.
— — *von Buch*. Über Ammoniten, p. 10, 1832.
— — *Hoffman*. Karstens Archiv, 13, p. 267, 1840.
— — *Zeuschner*. Neues Jahrbuch, p. 429, 1842.
— — *Quenstedt*. Das Flözgebirge Württembergs, p. 132, 1843.
— — *Portlock*. Geological Report on Londonderry, p. 132, 1843.
— — *d'Orbigny*. Paléontologie Française, Ter. Jurassique, p. 202, pl. l, 1842.
— — *Pilla*. Saggio compar. dei ter. d'Italia, p. 70, 1845.
— — *Simpson*. Monogr. of the Ammonites, p. 51, 1843.
— — *Murchison*. Geology of Cheltenham, 2nd ed., p. 89, 1845.
— NODULOSUS, *Buckman*. Ibid., p. 105, pl. xii, fig. 6, 1845.
— CONYBEARI, *Lardy*. Neues Jahrbuch, p. 210, 1846.
— — *Geinitz*. Grundriss der Versteinerungskunde, p. 289, 1846.
— — *L. Pilla*. Bulletin Soc. Géol. Franc., 2nd series, tom. iv, p. 1069, 1847.
— — *Quenstedt*. Cephalopoden, p. 80, tab. iii, fig. 13, 1846—9.
— — *Savi e Meneghini*. Consider. sulla Geol. della Toscana, p. 72, 1851.
— — *Von Buch*. Neues Jahrbuch, p. 316, 1851.
— — *Renevier*. Bulletin de la Soc. Vaud. sci. nat., tom. iii, p. 139, 1852.
— — *Merian*. Verhandlungen der naturf. Gessel. in Basel, p. 151, 1852.
— — *Chapuis & Dewalque*. Terr. Second. Luxembourg, p. 44, pl. v. fig. 4, 1853.

[1] 'Mineral Conchology,' vol. ii, p. 69, 1818.

Ammonites Conybeari,	*Escher.*	Neues Jahrbuch, p. 167, 1853,
—	— *Studer.*	Geologie der Schweiz, vol. ii, p. 30, 1853.
—	— *Simpson.*	Foss. Yorkshire Lias, p. 96, 1855.
—	— *Oppel.*	Die Juraformation, p. 78, 1856.
—	— *von Hauer.*	Die Cephalopoden aus dem Lias der nord. Alpen, p. 16, tab. ii, figs. 1—6, 1856.
—	— *Quenstedt.*	Der Jura, p. 69, 1858.
—	— *Terquem et Piette.*	Lias Inf. de l'Est de la France, p. 28, 1865.
—	— *Dumortier.*	Jurass. du Bassin du Rhône, t. ii, p. 22, 1867.
Arietites	— *Tate & Blake.*	Yorkshire Lias, p. 284, pl. vi, fig. 1, 1876.

Diagnosis.—Shell discoidal, much compressed; back tricarinated; whorls numerous, eight to ten, slightly involute and numerously ribbed; in adults ribs from forty to sixty in a whorl, small, round, obliquely arcuate, and interrupted, terminating at the outer carinæ; back rounded, with a large prominent obtuse keel, bounded by two deep sulci and two external lateral carinæ; aperture oblong, nearly quadrate.

Dimensions.—Transverse diameter of figured specimen 340 millimètres; height of aperture 60 millimètres; width of aperture 68 millimètres. A specimen measured by Professor Hauer was 90 millimètres in diameter; height of the last whorl $\frac{22}{100}$; width $\frac{23}{100}$; diameter of the umbilicus $\frac{60}{100}$ of the diameter of the shell.

Description.—This is one of the most characteristic and widely distributed species of the zone of *Arietites Bucklandi*, as shown by the table of synonyms prefixed to this article. Its form in general is very persistent, and its specific characters are subject to fewer variations than in most of the congeneric species. The specimen I have figured was obtained from the same locality as the type drawn by Sowerby, namely, the Bucklandi-beds of Salford, near Bath, from cuttings made during the formation of the Great Western Railway. Another very fine large typical example, which formerly belonged to me, collected at the same time and from the same locality, is now in the British Museum. "It measures 18 inches in greatest diameter, and 4 inches in thickness across its last chamber; eight whorls are capable of being counted, but the innermost portion cannot be made out." Dr. Henry Woodward, F.R.S., has kindly given me these measurements.

The adult shell consists of from eight to ten slightly involute whorls, about the width of their height; the inner whorls are nearly all entirely exposed, the turn of the spire only concealing a portion of the margin. The sides are convex and costated. The ribs are simple, narrow, obtuse, and slightly arched, and disappear at the outside of the lateral carinæ, near the dorsal sulci; they are numerous, and increase with the diameter of the shell; in the specimen I have figured there are sixty-eight ribs in the outer whorl; in general terms the number may be said to range from forty to sixty.

The siphonal area is broad and provided with a large obtuse prominent keel; on each side thereof is a deep sulcus bounded by an outer carina, so that the siphonal area of this shell is tricarinated with two sulci between.

The spire is composed of from eight to ten whorls, with convex costated sides, nearly all fully exposed; the outer whorl has a strongly developed tricarinate area.

Mouth-aperture nearly quadrate, with rounded angles. The septa, according to d'Orbigny, are symmetrical, foliated on each side, and divided into two or three lobes formed of nearly equal branches. The siphonal lobe is much longer and as wide as the principal lateral lobe, formed of a single narrow branch with four double digitations. Siphonal saddle much larger than the principal lateral lobe, and unequally divided by an accessory lobe (Pl. II, fig. 3). Principal lateral lobe formed nearly of symmetrical parts, the external branch sometimes provided with acute elongated digitations. Lateral saddle narrow, irregular and oblique. Inferior lateral lobe provided with two unequal branches. Sometimes there is a small auxiliary lobe. A line extended from the extremity of the dorsal lobe to the centre cuts three branches of the principal lateral, and passes above the three auxiliary lobes.

The following important observations were made by the late M. d'Orbigny,[1] on the development of *A. Conybeari*:

"This species is smooth only up to the diameter of 2 millimètres—rarely it remains so up to 3. It afterwards develops ribs similar to those of adult age, and has a small keel without lateral sulci; at the diameter of 12 millimètres it has often thirty-six ribs; at the diameter of 19 millimètres forty-six. In others this number is less, and that upon the less compressed specimens with large whorls. Upon these, for example, at the diameter 55 millimètres, there exists only thirty-five to forty ribs; upon individuals of 100 millimètres to 198 millimètres there were sixty-six ribs. In all the cases the lateral sulci on each side of the keel were not developed on the specimens observed up to the diameter of 30 millimètres. These differences in the number of the ribs, and in their proximity or separation, seem to appertain to the sexes, the shells with numerous ribs being probably those of the males. The lobes from early age have very nearly the same form. From the examination of a very large specimen it appears that the ribs disappear in extreme old age."

Affinities and Differences.—This species resembles *A. Kridion*, Hehl., from the Lower Lias, and figured in Zieten's 'Versteinerungen Württembergs,' tab. iii, fig. 2, and in d'Orbigny, 'Paléontologie Française,' Ter. Jur., tab. xxi, figs. 1—6. It is distinguished, however, from *A. Conybeari* by having fewer ribs, and these being more sharp and straight, and terminating in a prominent process near the back; the keel is more acute, and there are neither lateral sulci nor carinæ; the siphonal and lateral saddles have likewise a different form, and the phases of development of *A. Kridion*, according to d'Orbigny, are very different from those of *A. Conybeari*, the shell of the former remaining much longer in the embryonic state without ribs.

Locality and Stratigraphical Position.—This is a very characteristic shell of the Lower Lias. I have collected it from the Zone of *Arietites Bucklandi* in the deep

[1] 'Paléontologie Française, Ter. Jurassique,' tom. i, p. 204.

cuttings of the Bristol and Birmingham Railway near Bredon, at Fretherne-on-Severn, Coombe Hill, Purton-on-Severn,[1] and several other localities in Gloucestershire; Weston, near Bath; Saltford, near Bristol; Lyme Regis, Dorsetshire; and Robin Hood's Bay, Yorkshire.

Foreign Localities.—It characterises the Lower Lias in the Zone of *Gryphæa arcuata* in many Departments in France, as Cher, Jura, Ain, Meurthe, and Cote-d'Or; in Swabia it is collected at Vaihingen, Möhringen, Bebenhausen, and Nürtingen: for the other countries in Europe in which it is found the reader is referred to the table of synonyms.

History.—First figured by Sowerby, afterwards by Zieten, d'Orbigny, von Hauer, and Buckland. Their Plates are all good, and leave but little to be desired.

ARIETITES BISULCATUS, *Bruguière.* Pls. III and IV.

Robert Plot's Natural History of Oxfordshire, tab. 5, fig. 14, p. 110, 1677.
Martin Lister. Historia Angliæ, de Lapidibus turbinatis, tab. vi, fig. 3, p. 207, 1678.
Bourguet. Traité des Pétrefications, pl. 41, No. 270, 1742.

AMMONITES	BISULCATA,	*Bruguière* (pars). Encyclopéd. Méthod., t. i, p. 39, No. 13, 1792.
—	MULTICOSTATA,	*Sowerby.* Mineral Conchology, vol. v, p. 76, tab. 454, 1824.
—	—	*Zieten.* Versteinerungen Württembergs, p. 35, tab. xxvi, fig. 3, 1830.
—	BISULCATUS,	*d'Orbigny.* Paléontologie Française, Ter. Jur., p. 187, pl. xliii, 1842.
—	MULTICOSTATUS,	*Quenstedt.* Die Cephalopoden, p. 80, 1846—9.
—	—	*Quenstedt.* Handbuch der Petrefactenkunde, p. 355, 1852.
—	BISULCATUS,	*Chapuis et Dewalque.* Foss. Terr. Second. Luxembourg, p. 42, pl. v, fig. 3, 1853.
—	—	*von Hauer.* Die Cephalopoden aus dem Lias Nordöst. Alpen, p. 14, pl. i, figs. 3, 4, 1856.
—	—	*Oppel.* Die Juraformation, p. 77, 1856.
—	MULTICOSTATUS,	*Quenstedt.* Der Jura, p. 67, tab. vii, fig. 2, 1858.
—	—	*Terquem et Piette.* Lias Inf. de l'Est de la France, p. 26, 1865.
—	BISULCATUS,	*Dumortier.* Dépots Jurass. du Basin du Rhône, tom. ii, p. 20, pl. iii, figs. 1—3, 1867.
ARIETITES	—	*Tate & Blake.* Yorkshire Lias, p. 283, 1876.

Diagnosis.—Shell depressed, discoidal; siphonal area tricarinated; whorls subquadrate, with thirty to forty strong, sharp, bent ribs, having a tubercle near the siphonal margin of each; median keel strong, with two sulci and two lateral carinæ; aperture subquadrate, bisinuated anteriorly; lateral septa with three lobes.

[1] 'Proceedings of the Cotteswold Club for 1863,' p. 135.

Dimensions.—Transverse diameter of specimen figured on Pl. III, fig. 1, 200 millimètres; height of aperture 70 millimètres; width of aperture 64 millimètres.

Description.—The table of synonyms prefixed to this article is very limited when compared with the lists given in the works of Professors d'Orbigny and von Hauer; it is due, therefore, to the reader that I should give my reasons for excluding many of the citations of my contemporaries. In the description of *Arietites Bucklandi*, Sow.,[1] at p. 270, I have stated that M. Bruguière described, under the name of *Ammonites bisulcata*, two distinct forms—(A) *Ammonites Bucklandi*, Sow., and (B) *Ammonites multicostatus*, Sow.

The variety A had been previously figured by Martin Lister in his 'Conchyl. Angliæ,' p. 207, tab. 6, fig. 3; and by Lang in his 'Historia Lapidum Figuratorum Helvetiæ,' tab. 24, fig. 1. The variety B was included in Bruguière's general diagnosis of *Ammonites bisulcata*, and most authors have followed Bruguière in grouping both forms under one specific name. I am inclined, however, to think that Sowerby was right when he figured the two forms under distinct names. M. d'Orbigny and Professor von Hauer, in their works already cited, have figured good type forms of *A. multicostatus*, Sow. I assume that this is the recognised type of Bruguière's *A. bisulcata* in France and Germany, whereas the true *A. Bucklandi*, Sow., is seldom figured in any work on Lower-Lias fossils. I have, therefore, determined to retain Bruguière's name for his var. B, and Sowerby's name for var. A (see p. 270). In accordance with this view I have excluded all references to the synonyms of authors, unless I had a figure or a specimen for my guide, to determine the form referred to in the citation; this mode of proceeding has necessarily diminished the list, but makes it more correct for reference.

Arietites bisulcatus has a depressed discoidal shell, with a strongly tricarinated siphonal area and subquadrate whorls. The sides are provided with from thirty to forty simple, narrow, slightly-bent ribs, each terminating in a blunt tubercle, near the siphonal border. From the tubercle the rib bends sharply forwards, and disappears at the outer carinæ. The area is flat and tricarinated, the median keel a little more prominent than the laterals, and the two sulci, although well marked, are not very deep in the specimens I have examined; the lateral carinæ are well defined; the shell is bevelled off from the ridge to the row of tubercles, and presents a series of oblique undulations occasioned by the vanishing of the ribs. The spire is composed of subquadrate whorls; in a specimen, $5\frac{3}{4}$ inches in diameter, there are six whorls visible; on the outer whorl are thirty-seven ribs; on the second, thirty; on the third, twenty-nine; on the second, twenty-five; so that in this example the number of ribs increases with the number of the whorls. The aperture is quadrate, rather higher than wide, a little enlarged at the spire, and sinuous above, where it is marked by the central keel, the sulci, and lateral carinæ. (Pl. III and IV.)

The septa are symmetrical, foliated on each side, and divided into three lobes, and three saddles formed of unequal parts (Pl. III, figs. 1, 2, 3; Pl. IV, fig. 4). Siphonal

[1] 'Proceedings of the Cotteswold Naturalists' Club for 1863,' p. 135.

lobe narrow, one third longer and a little wider than the principal lateral lobe, having on each side five slightly unequal digitations. Siphonal saddle one fourth wider than the principal lateral lobe, and divided into three unequal parts by two unequal accessory lobes. Principal lateral lobe, a little longer than wide, has three foliated branches on each side. Lateral saddle nearly double the width of the principal lateral lobe, and divided into many unequal lobules. Inferior lateral lobe nearly as wide as the principal lateral, and divided into numerous unequal digitations. Auxiliary saddle half the size of the principal lateral lobe, divided into several unequal folioles. Auxiliary lobe narrow, descending much lower than the others, and formed of two branches, the one external and the other inferior.

Affinities and Differences.—This Ammonite strongly resembles *A. Bucklandi*, Sow.; it is distinguished, however, by having the whorls more quadrate, and the general form more angular; the forty to fifty ribs have each a tubercle near the outer border, from whence they curve sharply forwards towards the sulcus. In *A. Bucklandi* there are about twenty-four ribs, which gradually disappear on the siphonal area, and there are no tubercles near the angle of the sulcus. It is distinguished from *A. obtusus*, to which it has a general resemblance, by having narrower whorls, tuberculated ribs, and a much flatter siphonal area.

Locality and Stratigraphical Position.—This species has been found in the Zone of *Arietites Bucklandi* (Lower Lias) near Lyme Regis and Charmouth, on the coast of Dorset; at Weston near Bath; in the deep cuttings of the Bristol and Birmingham Railway, near Defford, Bredon, Cheltenham, and Gloucester, Coombe Hill, Highnam, and Berkeley, and in other localities in the Vale of Gloucester. The Warwick Museum contains some fine specimens from the Lima-beds of the Lower Lias in Warwickshire; and my late friend, Mr. John Leckenby, F.G.S., had several fine shells of this species collected from the Lower Lias at Robin Hood's Bay, on the coast of Yorkshire, which are now in the Woodwardian Museum, Cambridge.

Foreign Localities.—Germany—in Swabia and Württemberg (according to Professors Quenstedt and Oppel), it is abundant in the Bucklandi-beds of Bodelshausen, Vaihingen, Möhringen, and Gmünd. The Museums of Stuttgart and Tübingen contain many fine examples. In France from the same zone in the vicinity of Metz, (Moselle); and Avallon, (Yonne). The Museum of Sémur, Côte-d'Or; contains many fine shells from the Lower Lias near that town.

History.—The history of this species is curious and instructive; towards the end of the seventeenth century it was figured by Plot and Lister in this country, and by Lang and Bourguet on the Continent. In 1787, it was first correctly described in the 'Encyclopédie Méthodique' by M. Bruguière as *A. bisulcata*; he recognised two distinct forms, one with few ribs without tubercles, the other with numerous ribs having a tubercle on each. Sowerby, in his 'Mineral Conchology,' in 1818, figured the former as *A. Bucklandi*, the latter, in 1824, as *Ammonites multicostata*. Unfortunately this author entirely overlooked the excellent work previously published on Ammonites by

M. Bruguière. In 1830, Zieten figured as *A. multicostata* a good type specimen from the Lias Limestone of Altingen, near Tuttlingen, so that Bruguière's specific name was nearly forgotten, when Prof. A. d'Orbigny, in his 'Paléontologie Française,' in 1844, gave an excellent historical account of the species; this author, however, confused *A. Bucklandi*, Sow., with *A. bisulcatus*, Brug., an error which I have endeavoured to rectify in my description of these two forms.

ARIETITES ROTIFORMIS, *Sowerby*. (Pl. V, figs. 1—4; Pl. VII, fig. 1; Pl. IX, figs. 1—3.)

AMMONITES	ROTIFORMIS,	*Sowerby*. Mineral Conch., vol. v, p. 76, tab. 453, 1824.
—	OBLIQUE-COSTATUS,	*Zieten*. Die Verst. Würt., p. 20, t. xv, fig. 1, 1830.
	ROTIFORMIS,	*von Buch*. Über ammoniten, p. 10, 1832.
—	—	*Zieten*. Ibid., p. 35, tab. xxv, fig. 1, 1830.
—	—	*d'Orbigny*. Paléontologie Française, Ter. Jurassique, tom. i, p. 293, pl. lxxxix, 1842.
—	—	*Quenstedt*. Cephalopoden, p. 78, 1846.
—	OBLIQUE-COSTATUS,	*Von Hauer*. Jahrbuch geologischen Reichsanstalt, bd. vi, p. 736, 1853.
—	ROTIFORMIS,	*Studer*. Geologie der Schweiz, bd. ii, p. 30, 1853.
—	—	*Von Hauer*. Die Cephalopoden aus dem Lias der Nordöst. Alpen, p, 13, tab. 1, figs. 1, 2, 5, 1856.
—	—	*Quenstedt*. Der Jura, p. 67, tab. vii, fig. 1, 1858.
—	—	*Oppel*. Die Juraformation, p. 77, 1856.
—	—	*Dumortier*. Dépots Jurass. du Basin du Rhône, p. 22, 1867.
ARIETITES	—	*Tate & Blake*. Yorkshire Lias, p. 286, 1876.

Diagnosis.—Shell discoidal, compressed; siphonal area tricarinated; whorls numerous, quadrate, slightly involute, and strongly costated; ribs from twenty-seven to thirty in a whorl, simple, strong, arched, and terminating near the areal angle in a large, round, obtuse tubercle; siphonal area large and flat, with a median keel, two lateral sulci, and marginal carinæ; aperture quadrate, depressed, sinuous anteriorly.

Dimensions.—Transverse diameter of specimen figured on Pl. IX 175 millimètres; height of aperture 45 millimètres; width of aperture 40 millimètres. M. d'Orbigny's specimen: width of the last whorl $\frac{18}{100}$; portion overlapped of last whorl $\frac{2}{100}$; thickness of last whorl $\frac{20}{100}$; width of the umbilicus $\frac{65}{100}$ of the diameter of the shell.

Description.—Shell discoidal, compressed, with quadrate whorls, strongly ribbed, and slightly involute. In the specimen I have figured (Pl. V, fig. 1) the inner whorls are partly absent, and in part concealed; in Sowerby's type only four whorls can be counted, the central ones being absent; in d'Orbigny's fine specimen, which is almost perfect, there are eight whorls, and this we may regard as the normal number in a shell 180 millimètres in diameter; the number of ribs in a whorl differ much in different

specimens, thus in Sowerby's and Zieten's shells there are twenty-seven, in von Hauer's thirty-four, and in d'Orbigny's forty-five; they are simple, strong, and arched, and terminate near the margin in a large, round, obtuse tubercle. Sowerby says, "The ribs rising in knobs just as they reach the front give the whorls a very square aspect; the ribs and the hollows between them are nearly equal. The siphonal area is wide, in consequence of the extension given to this region by the size of the costal tubercles; upon the middle line of the back is a strong, thick, rounded keel, having on each side thereof a deep sulcus, bounded by lateral elevations, so that the area is tricarinated with two intervening sulci. The spire is composed of quadrate whorls, with prominent ribs, and a series of nodules along the curvature of the spire. The aperture is quadrate, depressed, and sinuous.

The septa of this species, according to Prof. A. d'Orbigny, are symmetrical, divided on each side into four lobes, of which the two lower lateral are formed of two equal parts. The siphonal lobe (Pl. V, fig. 2), one third longer than the principal lateral lobe, is ornamented on each side with a long denticulated branch. The siphonal saddle, one third wider than the principal lateral lobe, is formed of three divided lobules, of unequal size, of which the median is the largest. The principal lateral lobe terminates in two points, and has on each side three or four others. The lateral saddle, narrower than the principal lateral lobe, is formed of three unequal lobules, resembling those of the siphonal lobe. The inferior lateral lobe, half the width of the principal lateral, terminates in two points. The two auxiliary lobes are very small, and divide into one median and two lateral points. A line, parting from the extremity of the siphonal lobe, passes at a considerable distance from all the lobes externally visible, but touches the extreme spiral lobe, which is bifurcated, and accompanied on each side by a very large columellar saddle.

Affinities and Differences.—This species resembles in many characters *A. Conybeari*. It is distinguished, however, from that form by having a wider siphonal area and fewer ribs, each terminating in a large obtuse tubercle, the septa are likewise much more complicated than those of *A. Conybeari*. It resembles *A. bisulcatus*, Brug., in possessing simple ribs with marginal tubercles, and two deep sulci on each side of the median keel. It is distinguished, however, from that form in having narrower whorls, a larger umbilicus, and a very different lobe-line. Compare, for example, the sutures in Pl. III, fig. 2, with those in Pl. IV, fig. 2.

Locality and Stratigraphical Position.—This is a very rare Ammonite; my specimen was collected from the Lower Lias, near Lyme Regis; but its precise horizon I could not ascertain. Sowerby's specimen was found in the Lias, near Yeovil. I have seen fragments from a railway-cutting in the Lower Lias of Weston, near Bath, and from near Bristol, Somerset.

Foreign Localities.—Prof. d'Orbigny collected it from the Lower Lias, with *Gryphæa arcuata*, at Pouilly, Côte-d'Or, where it is rare. The fine shell figured in Pl. IX of this work came from near that locality, and was presented to me by Messrs.

Collenot and Bréon, of Semur, to help me in my comparative work; and I beg to return these kind friends my best thanks. Professor Quenstedt says it is most abundant in Germany, and is collected at Vaihingen, Möhringen, Gmünd. Professor von Hauer's figured specimen was collected in the Yellow Kössen Beds at Enzesfeld, near Vienna. Professor Studer found it in the Lower Lias of the Bernese Alps, and Lardy at Coulata and Fondement, near Bex, in the valley of the Rhone.

ARIETITES BROOKI, *Sowerby*. Plate VI, figs. 4, 5.

AMMONITES	BROOKI,	*Sowerby*. Min. Conch., vol. ii, p. 203, tab. 190, 1818.
—	—	*Zieten*. Verstein. Württemb., p. 36, tab. xxvii, fig. 2, 1830.
—	BROOKII,	*von Buch*. Über ammoniten, p. 10, 1832.
—	—	*Quenstedt*. Flözgebirge Württemb., p. 132, 1843.
—	BROOKI,	*Simpson*. Monogr. of the Ammonites, p. 53, 1843.
—	BROOKII,	*Quenstedt*. Cephalopoden, p. 80, 1846.
—	BROOKI,	*Oppel*. Juraformation, p. 83, 1856.
—	—	*Simpson*. Fossils of the Yorkshire Lias, p. 97, 1855.
ARIETITES	—	*Tate & Blake*. Yorkshire Lias, p. 284, 1876.

Diagnosis.—Shell depressed, strongly carinated, with a deep narrow sulcus on each side of the keel; whorls costated, with thirty-six strong, simple, arched, ribs, which curve round the inner margin of the whorl, and terminate at the sulcus; whorls half involute, inner volutions well exposed; surface of the shell marked with fine flexed lines of growth; aperture oblong.

Dimensions.—Transverse diameter of fig. 4, 140 millimètres; height of the outer whorl at the aperture 55 millim.; width 40 millim.; amount of involution one half the whorl.

Description.—This handsome, well-marked species is recognised by its compressed shell, ornamented with strong, simple, arched ribs, that are large and prominent, and equal in width to the valleys between them; the ribs curve round the inner margin of the whorl, arch regularly forward, and terminate at the areal angle of the outer margin of the sulcus; the siphonal area is sharp and angular; the keel round and prominent, with a deep furrow on each side, forming a well-marked boundary between the keel and sides. The surface of the shell is marked with fine flexed lines of growth, corresponding in flexure with those of the costæ; the siphuncle is lodged in the strong round keel.

Affinities and Differences.—This fine, boldly marked shell so much resembles *A. Turneri*, Sow., that it is difficult to discover the points of difference between them, whilst their affinities are numerous. In *A. Turneri* the shell is thicker and more quadrate, the siphonal area is broader, the ribs are nearly straight to the upper third of the whorl, where they bend abruptly forward towards the aperture, and form a kind of thickened eminence at the angle of flexure. In *A. Brooki* the upper third of the whorl slopes off, and the ribs, which are not so numerous, arch more regularly forward, forming the angle of flexure found in *A. Turneri*. This point of difference may be only one of sex,

for Sowerby says in his description of *A. Turneri*,—"The more exposed whorls, squarish aperture, and differently curved radii, distinguish this from *A. Brooki*, to which it bears a strong resemblance." If a larger series of both forms could be obtained, it is probable it would be found that they merged by a gradual series of gradations into one species; but, for the sake of convenience and easy reference, until more facts are brought to light, I have thought it best to figure good type forms of each, from which it will be seen that the affinities are many and the differences few and immaterial.

Locality and Stratigraphical Position.—*Arietites Brooki* is found in fine preservation, with the shell complete, at Lyme Regis, in beds of shale and Lower Lias Limestone; sometimes it is enclosed in crystalline masses of sulphuret of iron. It is on the whole a rare Ammonite.

ARIETITES SAUZEANUS, *d'Orbigny*. Pl. VIII, figs. 1 to 6.

AMMONITES	SAUZEANUS,	*d'Orbigny*. Paléontologie Française, Ter. Jur., p. 304, pl. xcv, figs. 4—5, 1842.
—	RESUPINATUS,	*Simpson*. Monogr. of the Ammonites, p. 15, 1843.
—	SPINARIES,	*Quenstedt*. Der Jura, p. 69, pl. vii, fig. 4, 1858.
—	TRANSFORMATUS,	*Simpson*. Foss. of the Yorkshire Lias, p. 91, 1855.
—	SAUZEANUS,	*Wright*. Monograph on the Asteroidea, Pal. Soc. vol. for the year 1861, p. 72, 1863.
—	—	*Dumortier*. Dépôts Jurass. du Bassin du Rhône, p. 132, pl. xxiv, fig. 1, 1867.
—	HALECIS,	*Buckman*. Murchison's Geol. of Cheltenham, p. 104, pl. xi, fig. 9, 1845.
ARIETITES	SPINARIES,	*Tate & Blake*. Yorkshire Lias, p. 286, 1876.
—	SAUZEANUS,	*Tate & Blake*. Ibid., p. 288, 1876.

Diagnosis.—Shell compressed, whorls quadrate, one third involute, ornamented with twenty costæ; the ribs are slightly bent, the convexity obliquely backwards, and they terminate in a tubercle at the outer margin of the siphonal area, which is flat, with a slightly elevated central ridge.

Dimensions.—The large specimen, transverse diameter 205 millimètres, height of aperture 67 millimètres, width of aperture 68 millimètres.

Description.—This remarkable Ammonite has an extremely quadrate physiognomy, the whorls, about one third involute, are square and ornamented in the large specimen figured with twenty ribs, which are simple, slightly bent with their convexity obliquely backwards, and they terminate at the angle of the margin in small well-marked tubercles (Pl. VIII, figs. 1, 2, 4). The siphonal area is large and quadrate, and a considerable eminence rises in the middle line, which, however, does not form a keel, nor are there any traces of lateral sulci as in the true keeled *Arietites*. The spire, formed of square-shaped whorls, imparts a

stair-like character to the open umbilicus (figs. 4 and 5). The aperture is quadrate (fig. 2), the width slightly exceeding the height. The septa are symmetrical, foliated on each side, and divided into four lobes with narrow branches; the siphonal lobe (fig. 3), long and narrow, projects beyond the others; the outer side has three short simple, two long branched, and one terminal branched digitation; on the inner side of each bilateral segment of the lobe there are five or six simple digits. The principal lateral lobe is small; it has five or six long tooth-like lateral digitations on its outer, three or four on its inner side, and bifurcates into two terminal branches; the inferior lateral lobe is long and slender, with several narrow digitations on the sides, and a bifurcate termination; the auxiliary lobe is small; the siphonal saddle is large, but not sufficiently exposed for accurate description; the lateral saddle is very large, occupying two thirds of the sides of the whorl; it has two large terminal folioles, and two lateral folioles, with four or five lobules in each.

Affinities and Differences.—In the quadrate outline of its whorls and its straight simple ribs its resembles *A. Valdani*, d'Orb.; and the terminal tubercle on its ribs likens it in form to *A. perarmatus*, Sow.; whilst the form of the lobes and saddles, and the median ridge on the back distinguish it from both. It is very distinct from the other species of keelless *Arietites*, and has no affinities with the keeled species of that group, the absence of sulci on the siphonal area affording a reliable diagnostic character.

Locality and Stratigraphical Position.—The large specimen was collected in the zone of *Arietites obtusus*, near Bredon, during the construction of the Bristol and Birmingham Railway. The smaller specimens were obtained from the same zone at Darlingscott, near Shipton-on-Stour, and given me by my late friend, Mr. John Kirshaw, of Warwick. I have found one or two small specimens in the Lower Lias of the Vale of Gloucester, and my friend, R. Etheridge, Esq., F.R.S., collected a specimen from the railway-cutting at Horfield, near Bristol. There are several fine large examples of this Ammonite in the stock cases of the British Museum; unfortunately their locality is unknown. *Arietites Sauzeanus* has been obtained from Lias nodules found in Drift on the Holderness Coast, and from the Lower Lias, Robin Hood's Bay, Yorkshire Coast. It is the true *Ammonites resupinatus* and *Amm. transformatus* of Simpson. It is curious that this remarkable Ammonite should have been found in England, France, and Germany about the same time.

Arietites Sauzeanus is a very rare Ammonite in France, M. d'Orbigny states that he had seen only two specimens of this singular species, which were collected from the *Gryphæa arcuata* beds of the Lower Lias by M. Boucault, at Champlong, near Sémur (Côte d'Or), where it is very rare.

ARIETITES CROSSII, *Wright*, nov. sp. Pl. X, figs. 1, 2.

Diagnosis.—Shell discoidal, large, compressed, sides with twenty-four ribs, narrow, sharp, and trenchant, much more developed near the line of involution than in any other part of their traject; they first bend backward, then arch forward, and finally vanish near the outer margin. They are thickest at the line of involution and become gradually thinner and less developed towards the margin, which is bevelled away. Siphonal area narrow, with a sharp, prominent keel, and a shallow sulcus on each side thereof.

Dimensions.—Transverse diameter of figured specimen 350 millimètres; height of the last whorl 10 millimètres; diameter of the umbilicus 170 millimètres; amount of involution one-third of the width of the whorl.

Description.—This very remarkable Ammonite was discovered by the Rev. J. E. Cross, F.G.S., in the Scunthorpe Ironstone of North-west Lincolnshire, in beds belonging to the Upper *Bucklandi*-series, containing *Arietites semicostatus*, *Aegoceras Boucaultianum*, and others. This new species attains gigantic size, as shown by several specimens in Mr. Cross's Collection. The whorls have their greatest thickness near the line of involution, from which they slope gently outwards toward the margin, so that the siphonal area forms a narrow and contracted space, in which the sharp, prominent keel, and two shallow sulci are found (fig. 2). The ribs likewise differ from those of other congeneric species, being largest and thickest near the line of involution, where in other forms they are most slender. They bend gently backward, then forward, diminishing in size as they ascend and disappearing near the outer bevelled margin of the siphonal area. The last whorl possesses twenty-five ribs, which have a uniform character throughout. The lobe-line was not seen in any of the specimens that passed through my hands. The narrowness of the siphonal area is very well exhibited in the capital drawing of Plate X, fig. 2.

The aperture of the shell is compressed—narrowest towards its outer margin and widest at the line of involution of the spine, and the last whorl embraces nearly one half of the penultimate one; the ribs are likewise nearly equidistant, narrow, and trenchant, and the curve they describe is uniform throughout all the whorls.

Affinities and Differences.—This large Ammonite resembles *A. Bucklandi*, but differs from that well-known species in the shape of the whorls: those of *A. Bucklandi* are square, and as wide at the siphonal as at the umbilical margin, whereas in *A. Crossii* they are contracted at the siphonal and large at the umbilical side; the ribs, moreover, in *A. Bucklandi* are small at the umbilical and large at the siphonal side, a character

which is quite the reverse in *A. Crossii*. The amount of involution is likewise much less in *A. Bucklandi*, and the keel is thicker and more pronounced in that form than in *A. Crossii*.

Locality and Stratigraphical Position.—This interesting Ammonite was found in the Scunthorpe Ironstone, associated, according to the Rev. J. E. Cross, with *A. Bucklandi*, *A. Conybeari*, *A. semicostatus*, *A. stellaris*, *Aegoceras Boucaultianum*, *Nautilus striatus*, *Belemnites acutus*, *Pleurotomaria Anglica*, *Cardinia gigantea*, and *Lima antiquata*, which are considered to represent the Upper *Bucklandi*-series, or zone with *A. semicostatus*. See p. 41.

I know of no other British specimens except those belonging to Mr. Cross's Collection. In the Museum of Stuttgart, however, I observed two very fine specimens of this species in the upright cases, unnamed, as they had been separated by Prof. Fraas from the true *Bucklandi* forms, and placed there as distinct. In the Museum of Tübingen, Professor Quenstedt kindly showed me another large specimen, and informed me that it came from the Upper *Bucklandi*-bed at Gmünd and Göppingen. My learned friend, who is most particular about the position of all fossils, assured me that it was the true horizon of this species, which I have named in honour of the Rev. J. E. Cross, F.G.S., its discoverer in the British Lias.

ARIETITES SEMICOSTATUS, *Young and Bird.* Pl. I, figs. 4—8.

AMMONITES	SEMI-COSTATUS,	*Young & Bird.* Geol. Surv. York. Coast., pl. xii, fig. 10, p. 257, 1828. (2nd. Edit.)
—	KRIDION,	*Hehl?* Zieten's Verstein. Württemb., p. 4, pl. iii, fig. 2, 1830.
—	NATRIX,	*Roemer.* Oolithen-Gebirg. i, p. 193, 1836.
—	KRIDION,	*d'Orbigny.* Pal. Française, Terr. Jurass., pl. li, figs. 1—6, p. 205, 1842.
—	SEMI-COSTATUS,	*Simpson.* Monogr. of the Ammonites, p. 51, 1842.
—	BODLEYI,	*Buckman.* Murchison's Geol. of Cheltenham, 2nd ed., p. 43, as crenata, pl. xi, fig. 7, 1845.
—	GEOMETRICUS,	*Oppel.* Juraformation, p. 79, 1856.
—	NODOSARIES,	*Wagener.* Verh. Nat. Ver., p. 161, 1860.
—	SPINARIES,	*Wagener.* Ibid., 1860.
—	GEOMETRICUS,	*Schloenbach.* Neues Jahrb., 1863, p. 164 ; Zeitsch. d. d. Geol. Gesellschaft, vol. xv, p. 500, 1863.
—	—	*Schloenbach.* Beiträge zur Paläontol., Palæontographica, vol. xiii, p. 155, pl. xxvi, fig. 3, 1865.
—	FALCARIES,	*Quenstedt.* Der Jura, p. 70, tab. vii, figs. 6, 7, 1858.
—	SEMI-COSTATUS,	*Simpson.* Fossils of the Yorkshire Lias, p. 93, 1855.

Ammonites geometricus, *Dumortier*. Dépôts Jurass. du Bassin du Rhône, tom. ii, p. 31, pl. vii, figs. 3—8, 1867.

Arietites semicostatus, *Tate & Blake*. Yorkshire Lias, p. 288, pl. vi, fig. 4 *a* (upper), 1876.

Diagnosis.—Shell discoidal, slightly involute, and depressed; whorls six, bearing straight, sharp, prominent ribs, which suddenly bend round the margin and vanish in the sulci; they are separated on the sides by well-defined concave spaces; the three inner whorls are almost always smooth. Siphonal area flat; keel narrow, sharp, and entire, placed between two lateral sulci; aperture quadrate.

Description.—This is a very common shell on the Yorkshire Coast, and a characteristic type of the group *Arietites*. It often occurs in rocky masses of Lower Lias Limestone in Robin Hood's Bay. One of those now before me contains twenty-five specimens on one side, and as many more clustered together in the slab, showing well the anatomy of the shell and the varieties of shape it assumes. In some the whorls are round and inflated, with the ribs slightly bent; in others the shell is flat and the ribs straight.

In early life, up to three or four whorls of growth, the sides are in general smooth, like *A. planorbis*, or have very slight folds, as indications of rudimentary ribs; and the keel begins to show itself as an elevated ridge without sulci. At this stage of growth the small shell resembles *A. radians*. In one of these young shells I exposed the black horny *Anaptychus in situ*. In Pl. I, figs. 7 and 8, I have represented these specimens the natural size. In one (fig. 7) the whorls are smooth; the *Anaptychus* is seen in this specimen, and fig. 8 shows the commencement of the ribbing. It was this half-ribbed character of the shell which suggested to Young the specific name *semicostatus*. In some young shells the keel has not been differentiated at the third whorl, and only then appears as a prominent rudimental ridge with slight crenations on the border.

The whorls are so entirely evolute that only the keel of the penultimate whorl is embraced by that which succeeds it; the increase of the whorls is thereby very slow, and their height is proportionately greater to the width in the growth of the shell, and the mouth-aperture forms in consequence a high rectangular opening.

The evolution of the shell is as follows: at first without ribs, and then it possesses only fine radial folds. About the third, fourth, or fifth whorls the ribs begin to show themselves, first as flat and indistinct folds, and soon afterwards as sharp, straight, prominent elevations. In a small shell with four whorls there are twenty-two ribs, in one with five whorls twenty-five ribs, and in one with six whorls there are thirty-six ribs. They all proceed in a straight line from the umbilical to the siphonal area, and at the marginal angle of the latter they bend abruptly forward and vanish in the sulcus. The body-chamber is three fourths of a whorl in length.

The lobe line is very simple (fig. 6); the siphonal lobe is short, with simple lateral serrations; the principal lateral is large, with small lateral digitations, terminating in two

branches. A small accessory lobe lies between it and the siphonal lobe, which is exaggerated in size in the drawing. The infero-lateral is small, and leads down to a small umbilical or auxiliary lobe.

Dimensions.—The following are the dimensions of four shells of from three to six whorls in each, with their parts and number of ribs, from some typical specimens before me:

Number of whorls	3	4	5	6
Do. ribs		22	25	36
Diameter of shell	15½ mm.	33 mm.	58 mm.	67 mm.
Width of umbilicus	7½ „	17 „	31 „	34 „
Height of the keel at aperture		1¼ „	2½ „	3 „
Do. last whorl	5 „	10 „	16½ „	19 „
Do. penultimate whorl	3 „	6 „	9½ „	11 „
Thickness of last whorl	4½ „	8 „	11 „	12 „
Do. penultimate	2½ „	5½ „	7¾ „	8 „

Young and Bird's figure of this shell is both bad and deceptive, and their description incomplete; hence arose early confusion about the species which they were the first to name, although it was well known to the Yorkshire collectors, who greatly prized the slabs crowded with its shells. Roemer collected it in Brunswick, and described it accurately, but erroneously identified it as *Am. natrix*, and placed it among the *Capricorni*. Quenstedt, in his 'Jura,' has figured and described it under the name *falcaries*, and Wagener under the names *nodosaries* and *spinaries*. In the Berlin Museum some English specimens, obtained from a dealer, have the true name *Am. semicostatus*. In the Jardin des Plantes the d'Orbignian collection contains the specimens which were figured in the 'Paléontologie Française' as *Am. kridion*, which I have examined. These shells have been collected from several well known Lower Lias localities, as Villefranche, Saône-et-Loire; environs of Lyons, Rhône; and Sémur, Côte-d'Or; Avallon, Yonne. An Ammonite was collected from the Lower Lias Limestone near Stuttgart, and called *Kridion* by Bergrath Hehl, and under this name it was figured by Zieten in his large work on Württemberg fossils. This shell has been frequently mistaken for *A. semicostatus*, but appears to be distinct; it was erroneously identified by d'Orbigny with the French forms of *A. semicostatus*, and hence our species appears as *A. kridion* in the 'Paléontologie Française.'

Dr. Oppel, overlooking the fact that Young had figured, and Simpson well described, *A. semicostatus*, considered the shells he found in Robin Hood's Bay and at Lyme Regis a new species, and described them under the name *A. geometricus*, the *A. geometricus*, Phillips, having been found to be a form of *A. spinatus*.

Locality and Stratigraphical Position.—This Ammonite is found in the *Turneri-beds* or upper portion of the zone of *Arietites Bucklandi* at Broad Ledge, Lyme Regis,

whence I obtained a series of specimens in different stages of development, and where it is associated with *A. Turneri* and *A. Bonnardii*. It is found in the upper part of the zone of *A. Bucklandi*, Robin Hood's Bay, Redcar, Marske, Nunthorpe, Ellerbeck; and zone of *Amal. oxynotus*, Robin Hood's Bay, Yorkshire, and in the Lower Lias Shales and Limestones at Bredon, Lansdown, Cheltenham, and other places in the Vale of Gloucester.

Foreign Distribution.—In North Germany at Scheppau, Achim, Stadtoldendorf, Bundheim am Harz, Langelsheim am Harz, Brunswick; Salzgitter (Haverlah-Wiese), Hullersen and Wellersen, Hanover; and in many other localities.

In South Germany at Gmünd, Krummenacker, Göppingen, and Bebenhausen, near Tübingen.

ARIETITES BONNARDII, *d'Orbigny*. Pl. XI, figs. 1, 2, 3.

AMMONITES BONNARDII, *d'Orbigny*. Paléont. Franç., Terr. Jurass., p. 196, pl. xlvi, 1842.

Diagnosis.—Shell discoidal; sides much compressed and ornamented with numerous (forty) ribs, which first arch backwards, then incline forwards, and finally bend round the margin, inclining obliquely forwards, and vanishing at the outer side of the sulcus. Siphonal area with a medium-sized keel between two deep lateral sulci. Aperture rectangular, subquadrate, compressed at the sides.

Dimensions.—Transverse diameter of the figured specimen, 110 millimètres; height of the last whorl, 25 millimètres; thickness of ditto, 22 millimètres. Amount of involution, 3 millimètres.

Description.—Shell discoidal, much depressed, carinated, and sulcated; whorls numerous (eight). The sides ornamented with forty ribs, mostly simple, rarely bifurcate, much arched, and rounded. The siphonal area broad, provided with a medium-sized prominent keel, having on each side a deep sulcus. The spire is composed of narrow compressed whorls, with very regular ribbing.

The aperture is rectangular, subquadrate, and compressed at the sides, with a prominent ventral process. The lobe-line is not shown on any of my specimens. D'Orbigny[1] describes the siphonal lobe as a little larger, and quite as long as the principal lateral, and ornamented with many conical digitations. The siphonal saddle is twice the size of the principal lateral lobe, and is divided into four round unequal leaves by three lobules, of which the central one has nine digitations. The principal lateral lobe is ornamented on each side with three branches, which increase in length from above downwards. The first has two digitations, the second three, and the third six; and the external branch is longer than the other. The lateral saddle, narrower than the principal lateral lobe, is unequally parted

[1] 'Paléontologie Française, ter. Jur.,' tome i, p. 196, pl. xlvi, fig. 3, 1842.

on the sides into large obtuse festoons. The infero-lateral lobe is small and provided outwardly with three, and inwardly with two, simple digitations, independently of the median point. The auxiliary saddle is very short and thrice festooned; the line from the central radius, in parting from the point of the dorsal lobe, touches the extremity of the principal lateral lobe, but is very distant from the infero-lateral and auxiliaries.

Affinities and Differences—This Ammonite retains its youthful form throughout life, and more nearly resembles *Arietites bisulcatus* than any other of the congeneric forms in the structure of its siphonal area, the general character of the shell, and the deep sulci on each side of the keel. It is distinguished from *A. bisulcatus*, however, specifically by the narrowness of the whorls, the compression of the sides, the greater number of ribs destitute of tubercles, and by the marked difference in the figure of the lobe-line, which is seen to be disposed in a different manner when the two species are carefully compared. It resembles *Arietites Turneri*, Sow., and I have seen *A. Bonnardii* marked *A. Turneri* in some continental museums; even Dr. Oppel appears to have thought them identical. It differs from *A. Turneri*, however, in having the whorls not nearly so high, nor the shell so thick as in that species; whilst the difference in the structure of the lobe-line makes a marked specific distinction between these two allied forms, which belong to the horizon containing the beds with *Pentacrinus tuberculatus*, Miller.

Locality and Stratigraphical Position.—I have collected this species at Lyme Regis, out of the hard limestone beds with *Aegoceras Birchii*; in a slab before me the two species are embedded together. It has been found in the same horizon in the Lower Lias of Bredon, Lansdown, near Cheltenham, and in the Vale of Gloucester.

I must refer the reader to p. 48 for an account of the *Turneri*-beds at Lyme Regis, and a list of the fauna with which *Arietites Bonnardii* was associated. *Aegoceras Birchii* may be now added to the list, as in a recent traverse I discovered the two Ammonites embedded together in the same slab.

Foreign Localities.—The type was found in the Lower Lias with *Gryphæa arcuata* in the environs of Belley (Ain). The type specimens are in the École des Mines, Paris. It has likewise been found by Dr. Oppel, near Stuttgart (Württemberg).

ARIETITES SUBNODOSUS,[1] *Young & Bird.* Pl. VI, figs. 2, 3.

AMMONITES SUBNODOSUS,	*Young & Bird.*	Yorkshire Coast, p. 258, 1828.
— —	*Simpson.*	Monogr. of the Ammonites, p. 48, 1843.
— —	*Simpson.*	Fossils of Yorkshire Lias, p. 90, 1855.
ARIETITES OBESULUS,	*Tate & Blake.*	Yorkshire Lias, p. 284, pl. vi, fig. 2, 1876.

Diagnosis.—Shell discoidal; sides flat, compressed; siphonal area broad, flat; keel

[1] Termed nodulosus on the explanation of Pl. VI, figs. 2 and 3.

prominent; sulci deep; area above the angle covered with oblique folds; ribs nearly straight for two-thirds their length, from suture to angle, where each rises into a small prominent tubercle; they then turn sharply towards the aperture, stretch obliquely forward on the area, vanishing at the outside of the sulcus. Whorls, five or six, inflated at the sides; inner whorls one-fourth concealed, outer whorl one-third the diameter of the shell; aperture subquadrate; diameter one inch and a half.

Dimensions.—Diameter of the figured shell, 42 millimètres; height of the last whorl, 15 millimètres; thickness of ditto, 11 millimètres; amount of involution, 4 millimètres.

Description.—After carefully examining this fossil I have arrived at the conclusion that it is not a distinct form of *Arietites*, but a variety of *Amaltheus Hawskerensis*, Young and Bird = *spinatus*, Brug., which has acquired an increased number of ribs, and converted the grooves on each side of the keel into sulci, resembling those of a true *Arietites*. Simpson says, in some specimens the radii are still closer, and the characteristic tubercles become nearly obsolete, until it can scarcely be distinguished from *A. geometricus*, Phil., which is in fact *Am. spinatus* with a notched keel. The rock in which *A. subnodosus* is fossilised appears to be the Marlstone of the Yorkshire coast, this species will, therefore, be noticed more in detail in the description of *Amaltheus spinatus*, Brug.

ARIETITES SCIPIONIANUS, *d'Orbigny*. Pl. XIII, figs. 1—3; Pl XIX, figs. 8—10.

AMMONITES	SCIPIONIANUS,	*d'Orbigny*. Pal. Française, Terrain Jurassique, p. 207, pl. li, figs. 7, 8, 1842.
—	PERSONATUS,	*Simpson* (*Bean's* MSS.). Monogr. on Ammonites, p. 9, No. 6, 1843.
—	—	*Simpson*. Fossils of the Yorkshire Lias, p. 38, 1855.
—	SCIPIONIANUS,	*Quenstedt*. Der Jura, p. 69, pl. viii, fig. 1, 1858.
—	—	*Dumortier*. Dépôts Jurassiques du Bassin du Rhône, tom. ii, p. 33, pl. viii, fig. 12; pl. ix, fig. 1, 1867.
—	—	*Collenot*. Descrip. Géologique de l'Auxois, p. 235, 1873.
ARIETITES	—	*Tate & Blake*. Yorkshire Lias, p. 287, pl. v, fig. 3, 1876.

Diagnosis.—Shell discoidal, compressed, acutely carinated; ribs numerous, slightly bent between the suture and marginal angle, where they terminate in blunt tubercles in young and middle-aged shells; sides flat, with from twenty-four to thirty-eight ribs. Siphonal area narrow, rather angular, with smooth sloping declivities, and a narrow, acute, prominent keel. Aperture hexagonal, compressed, and sharply angulated.

Dimensions.—Transverse diameter of specimen figured on Plate XIII, 150 millimètres; height of the last whorl, 50 millimètres; thickness of ditto, 35 millimètres; amount of involution, 8 millimètres; diameter of the umbilicus 60 millimètres.

Description.—This is a very remarkable Ammonite. In early life, its specific characters are well developed; in middle age it changes much; after attaining a very large size in its adult state it differs from all the previous conditions, as shown in specimens contained in the Museum at Semur, where this species may be studied in the different states of development. The shell is very thin, much compressed and carinate, provided with an elevated, but not cutting keel. The sides are flat and ornamented with numerous ribs, which vary in number in different individuals (from eighteen to thirty-six). They are thick and well developed when they appear at the umbilicus, and rise in straight lines, gently bent forward towards the aperture, and near the margin of the siphonal area terminate in small blunt tubercles. In the specimen I have figured from the Lower Lias of Gloucestershire (Pl. XIX, figs. 8—10) the ribs (seven in number) are far apart, the tubercles are small and conical, and the keel is sharp and prominent. In another specimen, about the same size as the latter, there are twenty-six ribs, so that the number of these lateral folds is valueless as a specific character in this form. In a larger specimen from the Museum of Semur, 165 millimètres in diameter, there are thirty-six ribs; and the fine specimen I have figured (Pl. XIII) from the same locality has twenty-eight ribs. The admirable figure given in this plate shows likewise another important feature in this Ammonite, namely, that the ribs, tubercles, and keel are much sharper and better defined in the cast than in specimens covered with the original shell. A small Semur specimen in my hand shows this very distinctly, and is verified, in Pl. XIII, in that portion of the outer whorl which has retained its shell. The ribs likewise in this species are rarely bifurcated.

The terminal costal tubercles appear to be best developed in early age; they gradually become blunted in the middle period, and finally disappear in the senile condition.

The keel is as well developed upon the cast as in those parts covered with the shell, and has almost always the same prominence; an anatomical fact of some importance, seeing that in a congeneric form, the *A. Aballoensis*, from a higher zone, as pointed out by Mons. Dumortier, the shell possesses a well-developed keel, which is entirely absent in the cast.

The lobe-line is delineated on Plate XIII; a lateral view in fig 1, and the siphonal and lateral lobes and saddles in fig. 3; this outline is essentially the characteristic form of the group *Arietites* to which this species belongs.

The aperture is compressed on the sides and forms an irregular hexagon; the two siphonal facets form prominent angles, the two sutural obtuse angles, and the lateral facets are inclined outwards.

Since the above description was in type, I have received, through the extreme kindness of M. Collenot, of Semur, a larger specimen of this species than the one figured

in Pl. XIII. It is an adult specimen with a considerable portion of the body-chamber and traces of the lobe-line. This fossil is 225 millimètres in diameter, the outer whorl at the aperture is 85 millimètres in height and 56 millimètres in width ; and the aperture is compressed and forms an irregular hexagon ; the two outer facets describe acute angles, the two lateral and the two inner re-entering angles. The whorls are widest at the umbilical, and narrowest at the outer margin, where they are bevelled away into the prominent keel. At the umbilical angle there are twenty-four thick, blunt ribs slightly inclined backwards, which ascend on the sides and disappear near the middle of the whorl, and then leave the upper portion smooth. The row of tubercles in which the lateral ribs usually terminate are absent on this more aged shell, so that the outer half of the whorl is bevelled away and rises into a high, prominent keel. A portion of the shell remaining on the cast shows how extremely thin the shell of this species was in so large an Ammonite. The keel, likewise, is as prominent on the cast as at the parts covered by shell.

The spire is formed of angular whorls, which are one half involute; they are all strongly ribbed as they appear near the umbilicus, the upper smooth-bevelled half being concealed by the involution of the spire. The body-chamber is not complete, still it occupies five sevenths of the outer whorl of this specimen.

The lobe-line is very tortuous, and forms three lobes and three saddles. The siphonal lobe is long, narrow, and freely digitate on each side. The siphonal saddle is wide and oblique, with numerous festoons on its long inner side (Pl. XIII, fig. 3); the principal lateral lobe is as wide, but shorter than the siphonal; and the lateral saddle is larger than the siphonal, and is oblique and festooned in like manner. The auxiliary lobes are small and indistinct.

This species attains a very great size, as may be seen in the old shells contained in the Semur Museum.

Affinities and Differences.—This Ammonite somewhat resembles *A. stellaris,* Sow., in the compression of the sides and bevelled surface of the outer margin. The row of tubercles near the siphonal area, the narrowness of that space and entire absence of sulci from each side of the keel, entirely separate it from *A. stellaris,* and there is no other form in the Lower Lias with which it has any affinities.

Locality and Stratigraphical Position.—It was collected from the Lower Lias Shales, in the Vale of Gloucester, during the deep cuttings made in the formation of the Midland Railway. In Yorkshire it is found in position in the upper part of the *Bucklandi* Zone at Marske, Redcar; and in Robin Hood's Bay, in blocks, associated with *Lima pectinoides, Lucina limbata, Dentalium elatense,* indicating the same horizon there.

In France it is found in the upper part of the zone of *Arietites Bucklandi* with *Arietites rotiformis* and *Ar. semicostatus,* Young, and is rarely discovered in the lower layers of the zone. Dumortier says it is collected at Saint-Didier, Rhône; also at Curgy, Borgy, Saône-et-Loire; Salins, Clomot, Nolay, Côte-d'Or; Mont-de-Lans, Isère; and

Avallon, Yonne. Near Semur, Côte d'Or, many specimens of a large size have been found, and which are now preserved in the Semur Museum.

In Germany, Quenstedt records it from Gmünd.

ARIETITES TURNERI, *Sowerby*. Pl. XII, figs. 1—6.

AMMONITES TURNERI, *Sowerby*. Mineral Conchology, tab. 452, vol. v, p. 75, 1824.

Diagnosis.—Shell discoidal, depressed, strongly carinated, with a deep narrow sulcus on each side of the keel; whorls costated, with forty-two strong, simple, straight ribs, which bend suddenly forward near the back, each rib thickened at the angle; inner volutions of whorls well exposed; aperture oblongo-quadrate.

Dimensions.—Transverse diameter 115 millemètres; height of the aperture 41 millemètres, width 38 millemètres; amount of involution nearly one fourth of the whorl.

Description.—This shell so closely resembles *Ammonites Brookii*, that I have long suspected it might only be a variety of that species; the want, however, of a good series of specimens of *A. Turneri*, to enable me to compare it with *A. Brookii* in different stages of growth, has induced me to retain, for the present, Sowerby's name, and to give his description of *A. Turneri* from vol. v, p. 75 of the 'Mineral Conchology. "Depressed, radiated, carinated, a furrow on each side of the keel; inner whorls exposed; radii numerous, equal, curved towards the front; the aperture oblong-quadrangular. Volutions about five, the inner ones almost wholly exposed; the radii are almost straight until they bend rather suddenly toward the front; the aperture is less than one third the diameter of the last whorl in length. The more exposed whorls, squarish aperture, and differently curved radii, distinguish this from *A. Brookii*, to which it bears a strong resemblance."

The septa are very imperfectly preserved in the specimen I have figured. The lobe-line shows the siphonal lobe (fig. 6) long, narrow, and deeply serrated on both sides, and the terminal branch bifurcated. The siphonal saddle is small, ending in two festoons; the principal lateral lobe (fig. 5) is oblique, and serrated, terminating in three curved digitations; the lateral saddle is wide, ending in three festoons, with several lobules on each side; the inferior lateral lobe is oblique like the principal lateral, and about the same size, with serrated sides and a trifid termination; the lower lateral saddle is much smaller than the upper lateral, and ends in three festoons of unequal size, with a lateral lobule on each side.

In Pl. XII, fig. 4, I have given an accurate drawing of one of Sowerby's original type specimens, now in the British Museum, to show its identity in form with the shell figured (figs. 1—3) on the same plate.

Affinities and Differences.—The affinities of *A. Turneri* to *A. Brookii* are so numerous, and the differences between them so few and inconsiderable, that I consider the question of their specific distinction one which requires further consideration; the affinities are more fully pointed out in the description of *A. Brookii*.

Locality and Stratigraphical Position.—The specimen figured was collected from a light-coloured clay and limestone in the deep cutting of the Bristol and Birmingham Railway, near Bredon, and was associated with *A. Bonnardii*, d'Orbigny, *A. semicostatus*, Y. & B., and several other Molluscs, with many fragments of the stems and side arms of *Pentacrinus tuberculatus*, Miller, and *Cidaris Edwardsii*, Wright.

ARIETITES OBTUSUS, *Sowerby*. Pl. XXI, figs. 1—5.

AMMONITES OBTUSUS, *Sowerby*. Mineral Conchol., vol. ii, p. 151, tab. 167, 1818.
— SMITHI, *Sowerby*. Ibid., vol. iv, p. 148, tab. 406, 1823.
— OBTUSUS, *Phillips*. Geology of Yorkshire, p. 136, 1835.
— — *Simpson*. Monogr. of the Ammonites of the Yorksh. Lias, p. 50, 1843.
— — *d'Orbigny*. Paléontologie Française, Terr. Jurassique, pl. xliv, p. 191, 1842.
— TURNERI, *Quenstedt*. Flözgebirge Würtembergs, p. 156, 1843.
— — *Quenstedt*. Cephalopoden, p. 77, tab. iii, fig. 19, 1846.
— OBTUSUS, *Chapuis et Dewalque*. Fossiles Terr. Second. Luxembourg, pl. iv, fig. 3; pl. v, fig. 1, p. 39, 1853.
— — *Simpson*. Fossils of the Yorkshire Lias, p. 92, 1855.
— — *Oppel*. Jura-Formation, p. 83, 1856.
— TURNERI (OBTUSUS), *Quenstedt*. Der Jura, p. 95, 1858.
— OBTUSUS, *Dumortier*. Dépôts Jurass. du Bassin du Rhône, t. ii, p. 122, 1867.
ARIETITES — *Tate and Blake*. Yorkshire Lias p. 287, 1876.

Diagnosis.—Shell thick, compressed, and tricarinate; carinæ obtuse; whorls subrotund, with twenty-five to thirty lateral ribs, which curve toward the aperture, are thick and obtuse, vanishing near the outer carina; lateral septa three-lobed; shell covered on all sides with fine longitudinal lines, twenty-eight on each side of the whorl, producing a series of punctations where they intersect similar transverse lines; aperture rotundo-compressed.

Dimensions.—The usual size is from 150 to 200 millimètres in diameter, but it attains 300 to 400 millimètres. Dimensions of the specimen figured in Pl. XXI, figs. 1, 2, transverse diameter 155 millimètres; height of the last whorl at aperture 65 millimètres; width 58 millimètres; width of the umbilicus 55 millimètres. The relative dimensions

calculated from several specimens are—height of the last whorl $\frac{40}{100}$; width, $\frac{35}{100}$; width of the umbilicus, $\frac{45}{100}$; involution of the whorl, $\frac{25}{100}$ of the diameter of the shell.

Description.—This Ammonite has a discoidal shell, moderately compressed on the sides, but rotund towards the siphonal area, which is furnished with a very thick obtuse keel, having on each side a deep sulcus separating it from two lateral carinæ formed by the angles of the sides and area ; aperture compressed, bi-sinuated at the summit, and strongly grooved by the turn of the spire ; whorls slightly compressed in the middle, and more so towards the upper third ; provided with from twenty-five to thirty moderately prominent acute ribs, which are arched, and disappear at the angle of the area before they merge into the lateral sulci ; the valleys between the ribs are very regularly concave.

The entire surface of the outer lamina of the shell is traversed by fine longitudinal lines, as if they had been cut by a graver. On the specimen before me there are sixty-six such lines on the area and sides of the whorl, and at the point where they intersect similar transverse lines a punctated depression is produced, which imparts a highly ornamental character to the shell of this species.

The septa are symmetrical, divided on each side into four lobes and four saddles, formed of unequal parts (Pl. XXI, fig. 5). The siphonal lobe is long and wide, and divided on the median line one third of its length, presenting numerous small equal-sized digitations around its circumference ; the siphonal saddle, as large as the siphonal lobe, has shallow ramifications on its outer side, and three small festoons on its anterior border ; the principal lateral lobe is conical, and about two thirds the length of the siphonal lobe ; the superior is larger than the siphonal saddle, and presents better developed simple festoons on its border than those on the latter ; the inferior lateral lobe is about as large as the principal, and has numerous small round digitations on its circumference ; the auxiliary saddle is about one fourth the size of the siphonal, and has a similar form ; the auxiliary lobe is nearly as large as the lateral.

Affinities and Differences.—This species very much resembles *Arietites stellaris*, Sow. ; so much so, that the one is often mistaken for the other. Both have longitudinal and transverse lines on the shell, and punctations at their points of intersection ; in *A. stellaris* the shell is more compressed and bevelled, the keel smaller and less obtuse ; the digitations of the lobes more complicated, and the saddles longer and narrower.

Locality and Stratigraphical Position.—This Ammonite characterises a well-marked zone of life in the Lower Lias, which was well shown at Bredon during the cutting of the Bristol and Birmingham Railway, from whence I obtained the fine figured specimens. The rock consisted of dark grey-bluish shales and marls, with irregular and inconstant bands of limestone. This Ammonite is found near Stratford-on-Avon, Warwickshire ; it is collected in great abundance between Lyme Regis and Charmouth, where the shells are replaced and their chambers filled with crystallised carbonate of lime. These beautiful fossils are called " Tortoise Ammonites " by the local collectors. The young examples of this species found with *A. planicosta*, Sow., in the Marston marble of Somersetshire,

which belongs to the zone of *A. obtusus*, have been figured by Sowerby under the name of *A. Smithi*.

In Robin Hood's Bay, on the Yorkshire coast, I have found this species, which, however, is very rare in that county, *A. stellaris* being here the dominant form, and mis-called *A. obtusus* in most of the public and private collections.

On the continent of Europe it has been found in France, in the environs of Avallon (Yonne); Saint-Ramber (Ain); and in the province of Luxemburg, at Ethe; and it is found in South Germany in many localities. Professor Quenstedt regarded this species as *A. Turneri*, Sow., and figured it as such; in pl. iii, fig. 19, of his 'Cephalopoden' my learned friend recognised the stratigraphical importance of this form, as he found it characteristic of a zone, which he called the "*Turnerithone*" in his valuable 'Flözgebirge Würtembergs.' It is found at Balingen, Ober-Dingen, Betzgingen, and Betzenrieth.

ARIETITES STELLARIS, *Sowerby*. Pl. XXII, figs. 1—6.

AMMONITES	STELLARIS,	*Sowerby*. Mineral Conchology, vol. i, p. 211, pl. 93, 1815.
—	—	*De Haan*. Mon. Ammon. et Gon., p. 109, 1825.
—	—	*Guidoni*. Journal de Géologie (Boué), iii, p. 276, 1831.
—	—	*d'Orbigny*. Paléontologie Française, Terr. Jurassique, t. i, p. 193, pl. xlv, 1842.
—	—	*Pilla*. Bull. Soc. Géol. de France, sér. ii, t. iv, p. 1063, 1847.
—	TURNERI,	*Quenstedt*. Die Cephalopoden, p. 261, 1846—9.
—	STELLARIS,	*Schafhäutl*. Von Leonhard und Bronn's Jahrbuch, p. 139, 1848.
—	—	*Savi e Meneghini*. Geologia della Toscana, p. 104, 1851.
—	OBTUSUS,	*Ehrlich*. Geognostich. der Nordöstlich. Alpen, p. 22, 1852.
—	STELLARIS,	*von Hauer*. Jahrbuch der k. k. geolog. Reichsanstalt, iv, p. 747, 1853.
—	—	*Chapuis et Dewalque*. Foss. terr. second. Luxembourg, p. 41, pl. v, fig. 2, 1853.
—	—	*Merian*. Verhand. der Natur. Gesellschaft. Basel, p. 77, 1854.
—	—	*von Hauer*. Die Cephalopoden aus dem Lias, Nord-Alpen, p. 22, pl. v, figs. 1—3, 1856.
—	—	*Oppel*. Juraformation, p. 82, 1856.
—	—	*Quenstedt*. Der Jura, p. 96, pl. xii, fig. 1, 1858.
—	—	*Dumortier*. Dépôts Jurass. du Bassin du Rhône t. ii, p. 123, 1867.
ARIETITES	—	*Tate & Blake*. Yorkshire Lias, p. 287, 1876.

Diagnosis.—Shell discoidal, compressed; whorls four, exposed, one third involute; sides flattened, covered with thirty ribs, nearly straight on the sides, and bent toward

the marginal angle; siphonal area squarish with a thick prominent keel, and two deep lateral sulci. Outer lamina of the shell ornamented with elevated longitudinal and transverse lines, growing at some distance apart and forming decussating striæ with a series of elevations at the points of intersection; aperture oblong, subquadrate, deeper than wide; siphonal area narrow and bisulcate; dorsal margin widest where it embraces the penultimate whorl.

Original type specimens of Sowerby—the largest shell (Pl. XXII, figs. 1, 2):—

Dimensions.—Transverse diameter 125 millimètres; width of umbilicus 40 millimètres; height of aperture 50 millimètres; greatest dorsal width 43 millimètres.

Smaller shell (Pl. XXII, figs. 3—6), the same as figured in the 'Mineral Conchology': transverse diameter 73 millimètres; width of umbilicus 25 millimètres; height of aperture 30 millimètres; greatest siphonal width 25 millimètres.

Description.—The shell is discoidal, compressed; tricarinate on the siphonal area, and its sides ornamented with thirty simple ribs, slightly bent in the inner half, curved forward, and much less prominent as they approach the angle; the shell is bevelled away toward the abdominal side, and here the ribs entirely vanish. The siphonal area is narrow from the bevelling of the shell; the keel is thick and prominent (figs. 2 and 5), with a deep sulcus on each side. The spire is composed of four compressed whorls, which cover more than a third, about $\frac{38}{100}$th of the embracing whorl, so that the entire umbilicus is exposed. The surface of the outer lamina of the shell is ornamented with distant, elevated, longitudinal, and transverse lines, and the decussating striated surface thus produced forms small tubercles at the points of intersection, which impart a remarkable feature to this and the allied species, *Arietites obtusus*. These decussating striæ are very well shown in the siphonal areas of both the figured specimens; the aperture is oblong, subquadrate, compressed at the siphonal side, with a sinuous margin, and enlarged at the umbilical side, where it embraces the preceding whorl.

The lobe-line, very well shown in fig. 3, forms one siphonal, and three lateral lobes, with four saddles on each side. The siphonal lobe is one third longer and wider than the superior lateral lobe, which is small, and the lower lateral and the auxiliary are so likewise. The lateral saddles are very large, and much exceed in size the siphonal and auxiliary saddles, as is very well seen in figs. 3 and 6. In none of the specimens that have passed through my hands have I seen the form and complexity which d'Orbigny has figured in his plate xlv.

The *Anaptychus*, which I found in the body-chamber of a large specimen at Lyme Regis, has an uneven, compressed, bell-shaped figure; it has a horny texture, and much resembles the Anaptychus of *A. semicostatus* found very near the *obtusus*-zone.

Affinities and Differences.—*Arietites stellaris* very much resembles *A. obtusus* (Plate XXI) in the general form and punctated character of its shell structure; it differs, however, from that Ammonite in having a more compressed shell, bevelled away toward the margin, with more numerous ribs vanishing as they approach the angle, and leaving no

trace in the siphonal area. The lobe-line likewise differs from that species, being in general more simple throughout.

It resembles *A. bisulcatus*, Brug. (Plates III and IV), in its form, ribs, and keel, but is readily distinguished from it at all ages by the size of the whorls, the more compressed sides, the bevelling away at the outer margin, the complete absence of tubercles on the sides, and the difference in the contour of the lobe-line.

In youth the ribs in *A. stellaris* are more acute, in the adult they become blunted, in old age are nearly effaced and the prominent carina becomes much attenuated.

It very much resembles *A. Turneri* (Plate XII), but differs from that form in having fewer ribs, all of which disappear on the bevelled margin; whilst in *A. Turneri* they are bold and well-defined throughout. The longitudinal and transverse elevated lines, on the shell surface, finely punctated at their intersections, are absent in *A. Turneri*. The same structural differences distinguish *A. stellaris* from *A. Brooki* (Plate VI), with which it has many affinities in point of form and style of growth. The shell surface, however, forms an important diagnostic character between two such closely allied congeneric forms.

This is a very important species, and highly characteristic of a well-marked zone of life in the Lias Sea. Prof. Quenstedt described this form as *A. Turneri*, and assigned its true position in his 'Flözgebirge Würtembergs,' p. 156, from its abundance in a bed of clay of his "Betakalk," called "Turnerithone," which he found at Erms by Betzingen, near Balingen, and Bollerbach between Heiningen and Betzgenrieth.

Dumortier says that it is the most important and characteristic shell of the strata in which it is found, and is the most widely distributed, and is assuredly the fossil the most easy to observe; seeing that its fragments cannot escape observation, inasmuch as the specimens are almost always of large size.

Locality and Stratigraphical Position.—The finest specimens of this species are found in the limestone nodules of the *Arietites-obtusus* zone between Broad Ledge and Cornstone Ledge, near Charmouth, Dorset. I have found some large specimens in the same zone in the Bredon cutting of the Midland Railway, and at Robin Hood's Bay, Yorkshire (see page 54). Many of these specimens are preserved in the Leckenby Collection, now in the Woodwardian Museum, Cambridge.

Foreign Distribution.—South Germany, Würtemberg, at Ballingen (Quenstedt); Austria, in the North and South Alps (Von Hauer). France: Avallon, Yonne; St. Fortanat, St. Cyr, Dardilly, Rhône (Dumortier); Mont-de-Lans, Isère (Gras); Nancy, Meurthe, and other localities, together with those recorded in the works cited in the bibliography of this species.

ARIETITES RARICOSTATUS, *Zieten.* Pl. VII, figs. 2—6; Pl. XXVI, figs. 5—14.

AMMONITES RARICOSTATUS, *Zieten.* Versteiner. Würtemb., p. 18, tab. 13, fig. 4, 1830.
— — *De Mandelsloh.* Const. géolog. Alb. Würtemb., 1835.
— — *d'Orbigny.* Terr. Jurass., tom. i, p. 213, pl. 54, 1842.
— CARUSENSIS, *d'Orbigny.* Terr. Jurass., i, p. 284, pl. 84, figs. 3—6, 1842.
TURRILITES BOBLAYEI, *d'Orbigny.* Terr. Jurass., i, p. 178, pl. 41, 1842.
AMMONITES RARICOSTATUS, *Quenstedt.* Flötzgeb. Würtemb., p. 159, 1843.
— — *Quenstedt.* Petrefactenkunde, p. 83, tab. 4, fig. 3.
— — *Fraas.* Würtemb. Jahresb., ii, p. 210, 1846.
— — *Bronn.* Gesch. d. Natur, iii, p. 57, 1847.
— — *Giebel.* Geogn. Septentr. Hercyn. fast. constit., p. 19, 1848.
— — *Hehl.* Geogn. Würtemb., p. 218, 1850.
— — *Schafhäutl.* Südbayr. Alpen, p. 138, 1850.
— — *Renevier.* Bull. Soc. Vaud. Sc. Nat., t. iii, p. 139, 1852.
— — *Studer.* Geologie der Schweiz, ii, p. 30, 1853.
— — *Von Hauer.* Cephalopod. aus dem Lias N.-O. Alpen, p. 52, pl. xvi, figs. 10—12, 1856.
— — *Quenstedt.* Der Jura, p. 105, pl. xiii, figs. 16—18, 1858.
— EXORTUS, *Simpson.* Foss. of Yorksh. Lias, p. 44, 1855.
— RARICOSTATUS, *Dumortier.* Dépôts Jurass. du Bassin du Rhône, tome ii, p. 173, pl. xxv, figs. 4—7, 1867.
AEGOCERAS? RARICOSTATUM, *Tate and Blake.* Yorksh. Lias, p. 276, 1876.

Diagnosis.—Shell compressed, discoidal; whorls narrow, numerous, almost entirely evolute; sides with 21 to 30 straight, acute, prominent, and distant ribs, diminishing in size on the siphonal area, which is flat, with a small, narrow, rudimentary keel, without lateral sulci; aperture quadrate, rotundo-cordate.

Dimensions.—The large specimen figured in Pl. VII, figs. 2, 3, 4. Diameter 93 millimètres; ditto of umbilicus 56 millimètres; height of aperture 20 millimètres; width of ditto 18 millimètres.

The smaller specimen figured in Pl. XXVI, figs. 12, 13, 14: diameter 60 millimètres; ditto of umbilicus 35 millimètres; height of aperture 15 millimètres; width of ditto 15 millimètres.

Dimensions of the French specimen measured by A. d'Orbigny: diameter 93 millimètres; size of the last whorl $\frac{20}{100}$; amount of involution $\frac{2}{100}$; diameter of the umbilicus $\frac{62}{100}$; thickness of the last whorl $\frac{22}{100}$. Another, measured by M. Dumortier, gave: diameter 65 millimètres; size of the last whorl $\frac{22}{100}$; thickness $\frac{21}{100}$; size of umbilicus $\frac{64}{100}$. In a smaller shell of 35 millimètres all the other proportions remain the same.

Description.—This is an important and very characteristic Ammonite, as it marks

out clearly the boundary line between the Lower and Middle Lias, and has a very limited life in time.

It presents two distinct forms, both of which are met with in the British Lias, and each requires a separate description. The first variety (*a*) is the form which has been figured by Zieten as the type of the species. It has straight prominent ribs, set far apart, with wide concave spaces between. We count about twenty costæ in the last whorl of a shell of 60 millimètres in diameter; when the Ammonite is larger the whorls have more prominent ribs, which become thicker at the margin. The fossil, Pl. VII, fig. 2, is a good example of this form; in it, however, the ribs are more numerous, on account of the size of the shell. Those which I have collected near Cheltenham, and those found at Ballintoy, in the North of Ireland, belong to this variety.

The second variety (*b*) has more numerous ribs, nearly thirty in the last whorl, in a shell of 40 millimètres in diameter. The whorls are in general less depressed, and the inner are covered with very delicate, close-set, regular ribs. The evolution of this variety is very well shown in a mass of specimens I obtained from a bed of shale near Charmouth. The young shells of 16 millimètres in diameter all have numerous bent ribs, set very regularly apart, which cross the siphonal area without any trace of the carina which appears in larger specimens; so it may be said of this Ammonite that the young shells have many more ribs in a whorl than the older specimens. The carina first appears as a slender central sheath, which only assumes the form of a rudimentary keel when the shell reaches from 20 to 25 millimètres in diameter. This variety is collected in great numbers from the upper beds of the Lower Lias Clay near Charmouth. The shells, however, are so highly charged with iron sulphuret that they unfortunately soon fall to pieces in the drawers of the cabinet by the decomposition of the mineral matrix.

The septa are very distinct in this species, and removed rather wide apart. They form three lobes, and three saddles composed of unequal parts. The siphonal lobe is a little longer than the principal lateral lobe (Pl. VII, fig. 5), and has numerous denticles on its sides. The siphonal saddle is one third larger than the principal lateral lobe, and has three groups of lobules nearly equal in size; the principal lateral lobe is irregular in the shape and disposition of its lateral denticles; the lateral saddle is smaller than the principal lateral lobe, and has two terminal lobules with small lateral branches; the lower lateral lobe is small, with several lateral denticles, and the auxiliary lobe ends in simple digitations.

The septa stand wide apart, and the lobe-line occupies the valley between every second rib, as shown in fig. 6, drawn purposely to demonstrate this remarkable character in the structure of *A. raricostatus*, which is really not only raricostate, but likewise rariseptate, in all the specimens I have examined.

The front view (Pl. VII, fig. 4) shows the plain siphonal area deprived of the shell, with the slender keel in the centre of the area; and the back view of the same shell shows

the same structural character around the whorl (fig. 3); the different examples of this species which I have figured in Pl. XXVI, figs. 5—14, show how permanent these characters are in several varieties of this species from my collection.

Affinities and Differences.—*Arietites raricostatus* stands out very distinct from all its other congeners; the short, straight, acute, sparse ribs on the sides, with wide concave valleys between; the narrow, slender keel, without lateral sulci on the area, and its simple lobe-lines so widely apart, form an assemblage of characters which readily distinguish this species from the congeneric forms with which it is associated.

Locality and Stratigraphical Position.—I have collected this species in the neighbourhood of Cheltenham, associated with *Hippopodium ponderosum*, *Arietites nodotianus*, and *Aegoceras densinodum;* the zone which it characterises I consider as the uppermost of the Lower Lias. At Black Venn, near Charmouth, Dorsetshire, a very interesting variety is found, unfortunately overcharged with iron-pyrites. The larger specimens, such as the one figured, Pl. VII, figs. 2, 3, are found in the limestone, and are well preserved.

At Robin Hood's Bay, Yorkshire coast, I found this species in nodules apparently derived from the *Oxynotus*-zone, which is here closely united with the *Raricostatus*-bed. I had a very fine series of this Ammonite sent me from the North of Ireland by my old friend Professor E. C. H. Day, F.G.S., which he collected from the *Raricostatus*-bed so well developed in the small Bay of Ballintoy.

In France it is found with *Gryphæa arcuata* at Semur, and at Pouilly-en-Auxois, Nolay, Côte-d'Or; near Nancy, Meurthe; Saint-Fortunat, Rhône; Saint-Cyr, Rhône; Drevaine, Saône-et-Loire, and several other localities in the Valley of the Rhone. In Württemberg it is found at Göppingen, Metringen, Oberdingen, Balingen, and Schlichen, near Schömberg.

ARIETITES NODOTIANUS, *d'Orbigny.* Pl. XXXVII, figs. 3 and 4.

AMMONITES NODOTIANUS, *d'Orbigny.* Pal. Française, Terr. Jurass., i, p. 198, pl. xlvii, 1842.
— MACDONELLII, *Portlock.* Report on Londonderry, p. 134, pl. xxix A, fig. 12, 1843.
— CHARPENTIERI, *Quenstedt.* Bronn's Jahrbuch für Mineral., p. 810, 1847.
— QUENSTEDTI, *Schafhäult.* Geog. Südbayr. Alpengebirg., p. 142, pl. xvi, fig. 22, 1851.
— NODOTIANUS, *Savi e Meneghini.* Geologia della Toscana, p. 122, 1851.
— — *Giebel.* De Cephalopoden der Vorwelt., p. 734, 1852.
— — *von Hauer.* Jahrbuch der k. k. geologischen Reichsanstalt, p. 747, 1853.

Ammonites nodotianus, *Studer*. Geologie der Schweitz, ii, p. 35, 1854.
— — *von Hauer*. Cephalopoden aus dem Lias N.-O. Alpen, p. 24, pl. vi, figs. 1—3, 1856.
Arietites ? Macdonnelli, *Tate and Blake*. Yorksh. Lias, p. 290, pl. v, fig. 8, 1876.

Diagnosis.—Shell discoidal, compressed, carinate; whorls one third involute, flat, and slightly convex, sides with numerous simple, straight, flat folds, 32—40 in the last whorl, most distinct between the umbilical border and the margin, and becoming evanescent and disappearing on the siphonal area, which is narrow and acute, with a thin prominent keel permanent in the cast; aperture narrow, elongated, elliptical, and compressed; on the sides a slight depression on each side of the keel; lobe-line simple; septa remote from each other.

Dimensions.—Diameter of figured specimen, 65 millimètres; width of umbilicus 35 millimètres; depth of the last whorl 15 millimètres; height of aperture 20 millimètres; transverse diameter of ditto 11 millimètres.

Description.—I am indebted to my old friend Professor Hull, F.R.S., for the loan of General Portlock's original type of *Ammonites Macdonnellii*, figured in his 'Geological Report of Geology of Londonderry,' and which belongs to the Dublin Museum of the Geological Survey of Ireland. The drawing did not do justice to the specimen. I have, therefore, had this shell carefully redrawn, with front and side views of the fossil.

I was the first to find this Ammonite in the English Lias in the zone of *Aegoceras Jamesoni*, sub-zone *armatus*, near Cheltenham. The shale in which it lies is highly ferruginous, and many of the specimens are much decomposed.

The shell is much compressed, discoidal, and strongly carinated; the whorls, seven in number, and about one third involute, are flat and only slightly convex; the sides are covered with numerous straight, simple folds or flat ribs (fig. 3), which are higher than they are wide, and a transverse section forms a regular ellipse. The height of the last whorl is about one fourth the diameter of the shell. The ribs, from 36—40 in the last whorl, are slightly elevated, and in shells of 60—70 millimètres are merely flat folds of the shell (fig. 3). In smaller specimens, 25 millimètres in diameter, they are regular and delicate ribs; about this age the keel first makes its appearance. As the shell grows, it becomes a thin, slender, prominent carina, which develops into a trenchant prominence on the shell, and forms (figs. 3 and 4) a well-marked carina on the cast. The ribs are largest between the umbilical border and the margin, where they diminish, and finally disappear on the siphonal area. The aperture is oblong, ellipsoidal, and compressed at the sides.

The lobe-line is very simple, all the lobes and saddles are slightly incised, and the septa placed wide apart; the siphonal lobe is a little longer than the principal lateral, and is tridigitate on each side. The principal saddle has three unequal festoons; the siphonal lateral lobe is fivefold; the lateral saddle is smaller, but similar to the siphonal. The lateral lobe is about two-thirds the size of the principal lateral, and terminates in

three digitations; the auxiliary saddles have small festoons, and the auxiliary lobe terminates in two points. The septa are placed so wide apart that we often find three ribs intervening between two septa. The radial line, in parting from the extremity of the dorsal lobe, cuts the points of the principal lateral lobe, but passes at some distance from the lateral lobe and the auxiliaries.

Affinities and Differences.—The compressed sides, prominent keel, and absence of lateral sulci, separate this form from other *Arietites* with which it is grouped, and with which it has many affinities both in the structure of the lobe-line and in the lobes and saddles themselves. It has numerous affinities with the genus *Harpoceras* in the form and structure of the shell.

Locality and Stratigraphical Position.—General Portlock found his type shell in the Lias at Larne, and others at Portrush and Ballintoy. I have found it in the lower part of the *Armatus*-bed at the base of the *Jamesoni*-zone in Lias Clays near Cheltenham, associated with *Aegoceras densinodum* and *Amaltheus oxynotus*.

In France it is very rare. The type specimen figured by d'Orbigny was collected in the Lias of Gros-Bois, Côte d'Or; Dumortier records it from St. Fortunat, Limonest, Rhône; Jambles, Saône-et-Loire; Nolay, Côte-d'Or, and other localities. Professor Von Hauer's specimen, figured in his 'Nordöstlichen Alpen' was found in the Lias of the Alps; at Neustiftgraben, Steinbauer, Adneth, Weidachlahne, in Ammergau. D. Stur collected numerous examples of this species, two to three inches in diameter, in the Carpathians at Modern, at Tureczka, and Arva.

Schafhäutl found it in the Bavarian Alps in several localities; Studer in Switzerland; and Savi and Meneghini in the Apennines at Castlenuovo in Garfagnana.

Arietites impendens, *Young and Bird.* Pl. XXII a, figs. 1—5.

Ammonites impendens, *Young and Bird.* Geol. Surv. Yorkshire Coast, p. 266, 1828.
— — *Simpson.* Monogr. of the Ammonites, p. 52, 1843.
— Fowleri, *Buckman.* Geol. of Cheltenham, p. 104, pl. xii, fig. 7, 1845.
— impendens, *Simpson.* Fossils of the Yorkshire Lias, p. 96, 1855.
— radiatus, *Simpson.* *Ibid.*, p. 88, 1855.
Arietites impendens, *Tate and Blake.* Yorkshire Lias, p. 290, pl. vi, fig. 7, 1876.

Diagnosis.—Shell discoidal, depressed, and highly carinate; whorls deep; sides convex and bevelled towards the margin, nearly two thirds involute; when *young*, sides costate, with thirty-six straight acute ribs, which bend sharply inwards toward the margin; *adult*, sides smooth or undulated with flat folds, which overhang the edge of the umbilical suture. Siphonal area narrow, with a very prominent acute keel, and two wide, deep lateral furrows; aperture narrow, compressed, or sagittate.

Dimensions (*young; costateform*, of specimen figured, Pl. XXII a, fig. 4).—Diameter 40 millimètres; ditto of the umbilicus 12 millimètres.

Middle-aged.—Diameter of specimen figured (Pl. XXII A, fig. 1) 80 millimètres; ditto of the umbilicus 26 millimètres; height of aperture 35 millimètres; width of ditto at spire 20 millimètres.

Adult.—Diameter of a specimen not figured, 100 millimètres; width of umbilicus 25 millimètres; height of last whorl 45 millimètres.

Description.—This is a very remarkable Ammonite, and combines in its structure the form of *Harpoceras* with the lobes and saddles of *Arietites*. It is likewise a very rare form in the Yorkshire Lias, where it has hitherto been chiefly found. In early age its deep whorls have costated sides, and when 40 millimètres in diameter (fig. 4) its convex sides are covered with thirty straight acute ribs, which bend sharply forwards toward the margin and disappear on the area; the keel is then acute and prominent, and it has a sulcus at each side. In middle age (when 80 millimètres in diameter, figs. 1—3) the last whorl has become very deep, and resembles a *Harpoceras* in form; about twenty bent ribs or undulating folds cover the sides near the umbilical suture, disappear on the external half, and are bevelled away toward the margin; the outer lamina of the shell is covered with numerous fine striæ, which follow the sweep of the ribs and highly ornament the surface—these lines are seen only on very fine specimens carefully extracted clean out of the shale; the height of the last whorl at the aperture in a specimen before me is about $\frac{50}{100}$ths of the diameter of the shell, that of the figured shell is $\frac{40}{100}$ths; the siphonal area is narrow, from the bevelling of outer half of the whorl; in the centre is a very acute prominent keel with two deep furrows (figs. 2, 3); in some good specimens the keel is beautifully crenated by the fine striæ of the shell passing over its edge. The inner margin of the whorls overhangs the umbilical suture, hence the origin of the name *impendens* given to this species by Young, and the outer margin terminates abruptly at the outer side of the sulcus (fig. 2). In the adult specimen, 100 millimètres in diameter, the depth of the outer whorl, and the size and prominence of the keel form striking characters in the shell, which is here intact; the amount of involution is likewise much increased.

The lobe-line (fig. 5) is very regular, the siphonal lobe is short and wide, and the margins finely striated; the siphonal saddle wide, with two festoons; the principal lateral lobe is less than the siphonal, and formed of unequal parts; the digitations are more numerous at the inner side; the principal lateral saddle is wide, with several festoons; the lateral lobe is a little smaller than the principal, and, like it, is formed of unequal parts; the lower lateral saddle is small, and the auxiliary lobes are concealed by the turns of the spire.

Affinities and Differences.—This Ammonite closely resembles *Arietites Collenotii*, d'Orb. They both have the physiognomy of *Harpoceras*, and might be readily mistaken for that genus, but the structure of the lobes and saddles closely connects them with *Arietites*, in which I have placed them. They are both rare Ammonites, and, except the specimen I obtained from Robin Hood's Bay, all the others were in the cabinet of my late

friend, Mr. John Leckenby, F.G.S., to whom the shell I have figured belonged; it was likewise the largest and finest example that had ever been found in Yorkshire. It is now in the Woodwardian Museum, Cambridge.

Locality and Stratigraphical Position.—This Ammonite was collected from the hard shales of the zone of *Amaltheus oxynotus* at Robin Hood's Bay, on the Yorkshire coast; the young form, figured and described by Prof. Buckman, F.G.S., as *Am. Fowleri*, was collected in the shales of the Lower Lias, in the deep railway-cutting near the Lansdown Station, Cheltenham.

ARIETITES COLLENOTII, *d'Orbigny*. Pl. VI, fig. 1[1]; Pl. XXII A, figs. 6—9; Pl. XXII B, figs. 1—3.

AMMONITES COLLENOTII, *d'Orbigny*. Pal. Franç., Terr. Jurass., p. 305, pl. xcv, figs. 6—9, 1842.
— DENOTATUS, *Simpson*. Fossils of York. Lias, p. 76, 1855.
— TENELLUS, *Simpson*. Ibid., p. 97, 1855.
ARIETITES COLLENOTII, *Tate and Blake*. Yorkshire Lias, p. 290, 1876.

Diagnosis.—Shell discoidal, compressed, volutions five to six; whorls deep, less than half the diameter of the shell, inner margin rounded, outer part depressed, sides costated; ribs straight for three-fourths of the whorl, then sharply bent towards the border; siphonal area small; keel narrow and acute, with two broad lateral sulci; sides convex, bevelled towards the marginal area; aperture narrow, deep, sagittate; septa with three lobes and three saddles.

Dimensions.—*Small specimen* with shell (Pl. XXII A, figs. 6—9): diameter 100 millimètres; ditto of umbilicus 22 millimètres; height of aperture 45 millimètres; width of ditto 23 millimètres; height of keel 6 millimètres.

Large specimen denuded of shell (Pl. XXII B, figs. 1—3): diameter 140 millimètres; height of the last whorl 65 millimètres; height of aperture 66 millimètres, width 33 millimètres; width of the umbilicus 30 millimètres.

Description.—This Ammonite has a compressed discoidal shell, provided with an acute prominent keel. In early age the sides have close and sharp costæ, which disappear in the adult state. A specimen, Pl. VI, fig. 1, 85 millimètres in diameter, has forty straight acute ribs, which increase in thickness near the margin, and bend sharply forward towards the aperture, entirely disappearing at the outer border of the sulcus. Pl. XXII A, fig. 6, is a specimen in which the shell is preserved; it is covered with minute striæ, which run parallel with the ribs, and these delicate lines passing over the keel give it a finely crenated appearance. The siphonal area is very narrow, from the bevelling away of the sides towards the outer border; the keel is acute and very prominent (Pl. XXII A, figs. 6—8), and on each side has a broad, shallow sulcus, outwardly

[1] Named *Arietites denotatus* on explanation of pl. vi.

bounded by a sharp carinated ridge, produced by the union of the costal termination, and forming a well-defined limit to the sulci. These marginal carinæ are well seen on the cast, but much better when the shell is preserved.

In the fine large specimen, Pl. XXII B, which measures 140 millimètres in diameter, the ribs begin to disappear from the last half of the whorl, whilst they are well developed upon all the inner turns of the spire. The keel is very sharp, the sulci broad, and the siphonal lobe-line is seen *in sitû* in fig. 3; the sagittal shape of the aperture is well seen in fig. 2, and the structure of the lobe-line in fig. 1. The septa (Pl. XXII A, fig. 9) consist of three lobes and three saddles. The siphonal lobe is much longer and wider than the principal lateral; it has two branches, the sides of which are ornamented with numerous bilateral digitations. The siphonal saddle (Pl. XXII B, figs. 1, 3) is as large as the principal lateral lobe, and provided with numerous rounded festoons. The principal lateral lobe curves outwards, has three digitations on its border, and terminates in several points; the lateral saddle is larger than the principal lateral lobe, and terminates in numerous festoons; the lateral lobe is divided into two parts, and each has several digitations; the lateral saddle is wide and shallow, and ends in six festoons; the auxiliary lobe is small, and terminates in two short branches.

In Pl. XXII A, fig. 9, I have given an enlarged drawing of the lobes and saddles of the specimen figured in No. 6, which agrees very well with the lobe-lines on the specimen drawn in Pl. XXII B, fig. 1, in which a line passing from the point of the siphonal lobe to the centre passes beneath all the other lobes.

Affinities and Differences.—This Ammonite very much resembles *A. impendens;* its keel, however, is larger, the last whorl is deeper, and it wants the overhanging projection over the umbilicus so characteristic of *impendens.* Notwithstanding these differences, *A. impendens* may be only a variety of *A. Collenotii.* It has some resemblance to *Arietites Brooki,* still the depth of the outer whorl and the absence of ribs in old specimens prove the distinctness of the species.

A. Collenotii is a very remarkable species, as was long ago remarked by Professor Alcide d'Orbigny, who observed that it united in one form two characters, in general widely separated from each other. In its general form it resembles *Harpoceras,* and in the structure of its lobes and saddles its affinities lie with *Arietites.* It is certainly very distinct from all the species of both groups, with which it has affinities and differences both interesting and remarkable. In its general form and structure, *Arietites Collenotii* resembles *A. Aballoensis,* d'Orb., but differs from the latter in having its prominent keel persistent on the cast, whilst in *A. Aballoensis* the keel exists only in the shell, and is entirely absent in specimens denuded of the carina; it likewise wants the lateral furrows so characteristic of *A. Collenotii.*

Dr. Oppel erroneously considered *A. Collenotii* to be a young individual of *A. Guibalianus,* and that both species should be united. It will be shown in the sequel,

however, by figure and description, that my late friend was mistaken in this conclusion, and that both are good type forms of well-marked species.

Locality and Stratigraphical Position.—The specimens I have figured belonged to my late friend Mr. John Leckenby, F.G.S., and are now in the Woodwardian Museum, Cambridge; they were collected from the Lower Lias at Robin Hood's Bay; the specimen figured in Pl. VI, fig. 1, from the same locality, has associated with it in the matrix several fragments of *Aegoceras lacunatum*, Buck. Mr. Blake says that this species comes from the middle portion of the *Oxynotus*-zone. Professor Alcide d'Orbigny's type was collected from the Lower Lias with *Gryphæa arcuata* at Champlong, in the environs of Semur, Côte-d'Or, from whence five examples had been obtained.

Family.—AEGOCERATITES—*continued.*

Genus II—Aegoceras. *Waagen*, 1869.

Family—Capricorni, *Von Buch.* Ueber Ammoniten, p. 12, tab. iv, fig. 4, 1832.
— *d'Orbigny.* Paléontologie Française, Terr. Crét., i, p. 411, 1841.
Coronarii, *d'Orbigny.* Ib., p. 414, 1841.
Arietes, *Quenstedt.* Cephalopoden, Kiellose Arieten, p. 72, 1849.
Capricornen, *Quenstedt.* Cephalopoden, pp. 80—92, 1849.
Ornaten, *Quenstedt*, pars. Ib. (*A. Henleyi, Taylori*), p. 132, 1849.
Coronaten, *Quenstedt*, pars. Ib., (*A. pettos, centaurus*), p. 175, 1849.
Macrocephalen, *Quenstedt*, pars. Ib., (*A. globosus*), p. 182, 1849.
Amalthei, *Giebel.* Fauna der Vorwelt, iii, p. 537 (*A. angulatus*), 1852.
Coronarii, *Giebel.* Ib., p. 659 (*A. pettos, Henleyi*), 1852.
Capricorni, *Giebel.* Ib., p. 678, 1852.
Ornati, *Giebel.* Ib., p. 692 (*A. Taylori, Charmassei*), 1852.
Capricorni, *Pictet.* Traité de Paléontologie, 2 ed., ii, p. 689, 1854.
Macrocephali, *Pictet.* Ib., i, p. 696 (pars), 1854.
Psilonoti, *Seebach.* Hannoversche Jura, p. 135, 1864.
Angulati, *Seebach.* Ib., p. 135.
Dorsati, *Seebach.* Ib., p. 136, 1864,
Capricorni, *Seebach.* Ib., p. 137, 1864.
Psilonoten, *Beyrich.* Cephalop. aus dem Muschelkalk der Alpen, p. 135, 1867.
Genus—Psiloceras, *Hyatt.* Foss. Cephalopods of the Museum of Comparative Zoology, Harvard Coll., Cambridge, Mass., p. 72, 1868. See also
Ophioceras, *Hy.* Ib. p. 75. Androgynoceras, *Hy.* Ib. p. 83. Cycloceras, *Hy.* Ib. p. 92.
Microceras, *Hy.* Ib. p. 80. Liparoceras, *Hy.* Ib. p. 83. Deroceras, *Hy.* Ib. 81.
Peronoceras, *Hy.* Ib. p. 85. Coeloceras, *Hy.* Ib. p. 87. Platypleuroceras, *Hy.* Ib., p. 92.
Aegoceras, *Waagen.* Formenreihe; Benecke Beitr., ii, 247, 1869.
— *Mojsisovics.* Jahrb. geolog. Reichsanst, p. 576, 1870.
— *Neumayr.* Zeit. Deutsch. geol. Gesellschaft, vol. xxvii, p. 905, 1875.

The form of the shell in this genus is very variable; it is flat and discoidal, with a wide umbilicus, or round and involute with a small umbilicus. In some shells the ventral margin is convex and enlarged, and the sides highly ornamented with ribs, tubercles, or elongated spines; in other species the sides have simple folds or undulations, as *Aeg. Jamesoni*, Sow. (Pl. XI, figs. 4—6); and some are smooth, as *Aeg. planorbis*, Sow. (Pl. XIV, figs. 1—4). The ventral side is in general round, *Aeg. capricornus*, Schlot. (fig. 186), and *Aeg. Davœi*, Sow. (fig. 187); sometimes it is grooved by a median channel, which interrupts the passage of the ribs from the right to the left side of the shell, as is especially the case in *Aeg. angulatum*, Schlot. (Pl. XIV, fig. 6), and *Aeg. Charmassei*, d'Orb. (Pl. XX, figs. 2, 3). In all the species a keel is absent, and there are no lateral longitudinal channels in the siphonal or ventral areas.

The body-chamber varies in length from two-thirds of, to an entire whorl. The mouth-border is simple; the edge has sometimes a thickened withdrawn lip and a ventral

Fig. 186.—*Aegoceras capricornus*, Schloth.

Fig. 187.—*Aegoceras Davœi*, Sow.

prolongation; and in *Aeg. planorbis* there is a contraction near the aperture (Pl. XIV, fig. 3), without lateral auricles. The *Aptychus* is horny, thin, and bivalved (Pl. XIV, fig. 3).

The lobe-line is much ramified, and the lobes in general are very complicated. There is a highly branched principal lateral, a smaller lower lateral; and the siphonal lobe, less than the principal lateral, ends in two divergent branches. There are several small auxiliary lobes near the suture, which are concealed by the involution of the spire, as in *Aeg. Charmassei*, d'Orb. (Pl. XX). This genus may be naturally divided into four sections:

First Section, Psilonoti.

Sides smooth, or with undulated folds or straight ribs; suture-line simple; ventral area round and smooth. *Aeg. planorbis*, Sow.; *Aeg. Johnstoni*, Sow.; *Aeg. torus*, d'Orb.; *Aeg. intermedium*, Portlock; *Aeg. Belcheri*, Simp.; *Aeg. laqueolus*, Schlönbach.

All these forms are found in the *Planorbis*-zone of the Lower Lias.

Second Section, Angulati.

Sides covered with sharply-flexed ribs, interrupted on the ventral area by a channel more or less developed. *Aeg. angulatum*, Schl.; *Aeg. Charmassei*, d'Orb.; *Aeg. catenatum*, Sow.; *Aeg. lacunatum*, Buck.; *Aeg. Boucaultianum*, d'Orb.

All these forms, the two last excepted, are from the *Angulatum*-zone of the Lower Lias.

Third Section, Armati.

Sides with numerous ribs, many of which develop tubercles or elongated spines; in some forms they are absent. *Aeg. Davœi*, Sow.; *Aeg. planicosta*, Sow.; *Aeg. Birchii*, Sow.; *Aeg. bifer*, Quenst.; *Aeg. armatum*, Sow.; *Aeg. Taylori*, Sow.; *Aeg. densinodum*, Quenst.; *Aeg. brevispinum*, Sow.; *Aeg. Valdani*, d'Orb.; *Aeg. Maugenesti*, d'Orb.

Aeg. planicosta, *Aeg. Birchii*, and *Aeg. bifer*, are from the Upper Bucklandi-beds of the Lower, and all the others are from the *Jamesoni* zone of the Middle, Lias.

Fourth Section, Involuti.

Shell highly involute; inner whorls sometimes almost entirely concealed. Shell during middle age often undergoes a great change of form, when the involution becomes less, and the umbilicus widens. *Aeg. Henleyi*, Sow.; *Aeg. striatum*, Reinecke; *Aeg. Bechei*, Sow.; *Aeg. curvicornum*, Schloenb.; *Aeg. pettos*, Quenst.; *Aeg. heterogenes*, Young and Bird.

All the forms of this section are from the *Henleyi*-zone of the Middle Lias. The genus *Aegoceras* began in the Muschelkalk, zone of *Arcestes Studeri*, with *Aeg. incultum*, Beyr., *Aeg. Palmai*, Mojs.; and became extinct in the Middle Lias.

First Section.—Psilonoti.

Aegoceras planorbis, *Sowerby*. Pl. XIV, figs. 1—4.

Ammonites planorbis,		*Sowerby*. Mineral Conchology, vol. v, p. 69, pl. 448, 1825.
—	erugatus,	*Phillips*. Geol. Yorksh., pl. 13, fig. 18, 1829.
—	psilonotus,	*Quenstedt*. Flötzgebirge Würtembergs, p. 127, 1843.
—	erugatus,	*Simpson*. Monogr. of the Ammonites of the Yorkshire Lias, p. 11, 1843.
—	Sampsoni,	*Portlock*. Geology of Londonderry, p. 136, pl. 29, fig. 13. 1843.
—	Hagenowii,	*Dunker*. Lias bei Halberstadt; Palæontographica, vol. i, p. 115, pl. xiii, fig. 22; pl. xvii, fig. 2, 1846.

Ammonites psilonotus lævis,	*Quenstedt.*	Cephalopoden, p. 73, pl. iii, fig. 18, 1849.
— —	*Quenstedt.*	Handbuch der Petrefactenkunde, tab. iii, fig. 18, p. 354, 1852.
— erugatus,	*Simpson.*	Fossils of Yorkshire Lias, p. 42, 1855.
— planorbis,	*Oppel.*	Juraformation, p. 73, 1856.
— psilonotus lævis,	*Quenstedt.*	Der Jura, p. 40, 1858.
— planorbis,	*Dumortier.*	Dépôts Jurass. du Bassin du Rhône, tom. i, p. 28. 1866.
Aegoceras planorbis,	*Tate and Blake.*	Yorkshire Lias, p. 270, 1876.

Dimensions.—Figured shell: diameter 85 millimètres; height of the last whorl 21 millimètres; width of umbilicus 47 millimètres.

Diagnosis.—Shell depressed, discoidal; whorls, seven to eight, slightly involute; sides covered with fine, straight, hair-like striæ, which are well seen on the outer lamina of the shell, and faintly visible on the cast; siphonal area narrow and rounded; aperture oblong, with a well-marked circular contraction; Anaptychus horny.

Description.—This Lias Ammonite is found nearly always crushed between shaly laminæ. Sowerby's original specimens from Watchet were in that condition, with the mother-of-pearl lamina well preserved. The natural form of the shell, however, is well shown in my figured specimen from the Yorkshire coast, and in another fine example from Würtemberg. The test is smooth, compressed, and discoidal, and the outer lamina of the shell is covered with fine, straight, hair-like lines of growth (Pl. XIV, figs. 1—3), which sometimes develop into folds; the siphonal area is round and smooth (fig. 2), and the body-chamber contracted near the aperture by a narrow oval band, which appears around that opening (fig. 3). The whorls, seven in number, increase very slowly in height; they are slightly involute, and the inner whorls are all fully exposed. The aperture is oblong and compressed on the sides (fig. 2); and the shell, almost as thin as paper, is preserved in part on both of the figured specimens, which have escaped compression. In nearly all the *Planorbis*-beds of England the delicate shells are crushed quite flat, and many of the points described above cannot be seen. In some of the fossils from Lias blocks washed up in Robin Hood's Bay, the casts of this Ammonite occur in a semi-transparent state, in which the sinuous lobe-line is beautifully displayed. The siphonal lobe (fig. 4) divides into two branches, with five serrations on each side; the siphonal saddle is about the same size, with five festoons; the principal lateral lobe is elongated and narrow, with asymmetrical digitations; the principal lateral saddle is larger than the siphonal; the lower lateral lobe is nearly as large and asymmetrical as the principal lateral; the auxiliary lobes are small and multidigitate. The lobe-line is very well seen in fig. 1, and an enlarged accurate drawing of the lobes and saddles is given in fig. 4.

Affinities and Differences.—In a recent important memoir,[1] Dr. M. Neumayr has added

[1] 'Zur Kenntniss der Fauna des untersten Lias in den Nordalpen,' p. 24. 1879.

several new forms to the division Psilonoti. The oldest representatives of this section, according to Beyrich, are found in the Muschelkalk of the Alps and of the Himalayas, as *Aeg. incultum*, Beyr., *Aeg. Salteri*, Beyr., *Aeg. Palmai*, Mojs. In the Rhætic beds of the Bavarian Alps, Dr. Gümbel found *Aeg. planorboides*, Gümb.; and in the Lower Lias the following species are recorded:

Aegoceras planorbis, Sow.
— *calliphyllum*, Neum.
— *Hagenowi*, Dunk.
— *torus*, d'Orbig.
— *Johnstoni*, Sow.
— *tortile*, d'Orbig.
— *crebrispirale*, Neum.
— *magus*, Neum.
— *Clausi*, Neum.

Aegoceras laqueus, Quenst.
— *laqueolus*, Schlönb.
— *Gernense*, Neum.
— *Suessi*, V. Hauer.
— *Aeduense*, d'Orbig.
— *Belcheri*, Simp.
— *intermedium*, Portlock.
— *liassicum*, d'Orbig.
— *Naumanni*, Neum.

In the absence of specimens wherewith to compare the minute differences which have been observed in the lobe-line of several of the forms in the preceding list, I must refrain from giving an opinion on the specific distinctions of the same, seeing that it is extremely difficult to arrive at a satisfactory conclusion as to forms which even have generally been admitted to be distinct, nor can a safe conclusion be attained unless we have before us several specimens showing the changes of form they assume at different phases of growth.

Prof. Quenstedt, in his 'Cephalopoden,' p. 73, admits two varieties, *Am. psilonotus lævis*, Qu., and *Am. psilonotus plicatus*, Qu.; the former with a smooth shell, and the latter with a folded or plicated shell. I have before me good examples of these varieties kindly sent by Prof. Fraas from the Stuttgart Museum, which fully bear out my learned friend's description.

The affinities and differences existing between *Aeg. planorbis* and other species of the section Psilonoti are numerous and not easily determined.

Locality and Stratigraphical Position.—I have collected *Aeg. planorbis* in the lowest beds of the Lower Lias, and whenever they are exposed it forms their most characteristic leading fossil. It is very abundant in the paper-like shales of this zone at Brockeridge and Defford Commons, Gloucestershire, at Burton, Wilmcote, and Grafton, Warwickshire; at Street, Uphill, and Watchet, Somersetshire; Penarth, Glamorganshire; and Pinhay Bay and Uphill, near Lyme Regis, Dorsetshire, where it is found in the upper part of the light-coloured argillaceous limestone, called there White Lias. On the Yorkshire coast it is found in large water-worn boulders of light-coloured limestone washed up by the tidal currents, and in the North Cliff of Robin Hood's Bay; and in Eston and East Coatham pits. The beds from which the masses are derived are out at sea, as the rock

is not found *in sitú* at low-water mark. The fine specimen, now in the Woodwardian Museum, figured in Pl. XIV, fig. 1, was broken out of one of these boulders.

Foreign Distribution.—In Würtemburg it is found in fine preservation at Nellingen and Riedern, near Esslingen, at Bebenhausen, near Tübingen, and in the vicinity of Rottweil. In France at Saulieu, and Beauregard, Côte d'Or, where it is associated with *Aeg. Johnstoni*, Sow., *Aeg. laqueus*, Quenst., and *Aeg. Burgundiæ*, Mart.; it is found likewise at Avallon, Yonne.

AEGOCERAS JOHNSTONII, *Sowerby*, 1824. Pl. XIX, figs. 3, 4.

AMMONITES	JOHNSTONII,	*Sowerby.*	Mineral Conchology, vol. v, p. 70, tab. 449, fig. 1, 1824.
—	TORUS,	*d'Orbigny.*	Pal. Franç., Terr. Jurass., p. 212, pl. liii, 1842.
—	JOHNSTONI,	*Oppel.*	Juraformation, p. 74, 1856.
—	—	*Giebel.*	Fauna d. Vorwelt, vol. iii, p. 738, 1852.
—	—	*Neumayr.*	Fauna der untersten Lias d. Nordalpen, p. 29, pl. iii, fig. 2, 1879.
AEGOCERAS	—	*Tate & Blake.*	Yorks. Lias, p. 271, 1876.

Diagnosis.—Shell discoidal, compressed; whorls, from eight to ten, depressed; sides convex, with thirty simple, short, oblique ribs, which occupy only the middle of the whorl, and are not developed on the inner or outer margins; siphonal areas rounded, and smooth; aperture subrotund.

Dimensions.—Diameter 90 millimètres; ditto of the umbilicus 58 millimètres; height of the last whorl 18 millimètres; width of ditto 17 millimètres; septa five-lobed.

Description.—Although this species is often quoted in lists of Lower-Lias Fossils, good specimens are extremely rare. I could not find one for figuring in either of the metropolitan Museums nor in those of the Midland Counties, where it is said to be common. Sowerby's original type belonged to Mr. Johnstone's cabinet, and was extracted from the slaty shales of the Lower Lias at Watchet, where it lies associated with *Aegoceras planorbis*. It is almost always much compressed, and the shell wants its outer lamina; the pearly inner layer is very brilliant and full of iridescent colouring. When the fossil is not compressed it assumes a different appearance, and comes out as *Am. torus*, d'Orbig., of which I have figured a typical specimen from Professor Deslongchamps' collection at Caen. This specimen is compressed, discoidal, and not carinated; the whorls are numerous, regular, and exposed (fig. 3), the spire consisting of nine whorls, which are extremely regular, and ornamented with thirty short simple ribs that occupy only the convex middle portion of the whorl; they do not extend either to the outer or inner margins of the same, and are wholly limited to the flanks; the other parts being smooth and destitute of ribbing. The siphonal area (fig. 4) is rounded and quite smooth, having

neither marks of striæ nor the merest rudiment of a keel on the cast (figs. 3 and 4). I have not seen the lobe-line of this species, and therefore quote d'Orbigny's description. The septa are symmetrical, divided on each side into five lobes and five saddles, formed of unequal parts. The siphonal lobe is as large, but shorter than the principal lateral, and its sides are ornamented on each side with four digitations; the siphonal saddle is one third larger than the principal lateral lobe, and divided into three obtuse folioles, the central leaf being the largest. The principal lateral lobe is ornamented on each side with two digitations; the superior is simple and terminates in a digitation with three points; the lateral saddle, as large as the principal lateral lobe, is divided into four obtuse unequal folioles; the inferior lateral lobe, very oblique and irregular, is half the length of, and much narrower than the principal lateral lobe. Besides these there are three oblique auxiliary lobes, represented by as many obtuse points. A transverse line, passing from the extremity of the siphonal lobe, cuts the extremity of the principal lateral, passes below the inferior lateral lobe, touches the extremity of the first auxiliary lobe, and cuts across the others.

Affinities and Differences.—This Ammonite differs from *Aeg. planorbis* in possessing more whorls, which are not so deep, and in having the middle of their sides covered with thick, short, blunt ribs, which vanish from the outer and inner margins. It has been considered by Dr. Oppel to be the *Aeg. psilonotum plicatum*, Quenst., still it differs from that Ammonite in possessing narrower and thicker whorls, rounder in form, and slower in growth, the sides of which have short, thick, inflated ribs, and a much wider umbilicus. It much resembles *Aeg. intermedium*, Portlock, from the Lower Lias of Ballintoy, County Antrim (Pl. XV, figs. 3—6). In this species, however, the ribs are more acute and curve forward toward the aperture (figs. 3 and 4); the siphonal area is likewise covered with fine cresentic folds (figs. 5 and 6); in other respects the resemblance is very great. The next Ammonite which stands in close relationship with *Aeg. Johnstonii* is *Aeg. Belcheri*, Simp.; the latter appears to resemble *Aeg. torus*, d'Orb., or the French form of *Aeg. Johnstonii*. These ribbed species of the Psilonoti section are very puzzling indeed, and a much larger number of specimens are wanted for comparison than we at present possess before correct determinations can be made out regarding them.

Locality and Stratigraphical Position.—At Watchet, *Aeg. Johnstonii* is found crushed flat in the shales of the lowest beds of the Lias. The mother-of-pearl layer of the shell is wonderfully preserved, the fossils shining forth in beautiful iridescent colours when the shales are laid open with the hammer; there are some fine large slabs covered with these iridescent Ammonites in the British Museum, which all came from Watchet; the form of the shell, however, cannot be made out from any of the specimens found in this locality. It is the constant associate of *Aeg. planorbis*, Sow., in British Liassic rocks, just as *Aeg. psilonotum plicatum*, Quenst., is the associate of *Aeg. psilonotum læve*, Quenst., in those of Würtemberg.

AEGOCERAS BELCHERI, *Simpson*. Pl. XV, figs. 7—9; Pl. XIX, figs. 1, 2.

AMMONITES BELCHERI, *Simpson*. Monogr. of the Ammonites Yorksh. Lias, p. 12, 1843.
— — *Simpson*. Fossils of the Yorksh. Lias, p. 43, 1855.

Diagnosis.—Shell discoidal, compressed; whorls narrow, numerous, from six to seven, exposed, rather flattened on the sides and rounded on the outer margin; ribs short, bent, blunt, and prominent, separated by concave spaces on the sides; siphonal area rounded, destitute of ribs, and marked with delicate, crescentic lines on the shell, which are partly impressed on the cast.

Dimensions.—Large specimen (Pl. XIX, figs. 1, 2) with shell:—number of whorls 6—8; diameter 95 millimètres; width of umbilicus 60 millimètres; height of the last whorl 20 millimètres; thickness of last whorl 18 millimètres; amount of involution one third of a whorl; number of ribs on the last whorl 48.

Small specimen (Pl. XV, fig. 7) without shell:—number of whorls 6—7; diameter 47 millimètres; width of umbilicus 31 millimètres; height of the last whorl 8 millimètres; thickness of ditto 5 millimètres; amount of involution one third of a whorl.

Description.—The two figures I have given of this Yorkshire Ammonite agree very well in comparative dimensions. The small specimen (Pl. XV) is entirely a cast, whilst the large fossil (Pl. XIX) has the shell nearly all preserved. In this Ammonite the ribs are rounded and directed obliquely forwards, the valleys between the elevations being about the width of the ribs, which commence near the umbilical margin, maintain an equal thickness on the sides, and disappear at the outer margin, leaving the round siphonal area entirely smooth and ornamented only by the fine crescentic lines of the shell. In those parts of the fossil where the shell is denuded we observe that the casts of the ribs are much more acute than where they are enveloped by shell. The umbilicus is very wide, and the growth of this interesting species was very slow.

The lobe-line is very complicated; Pl. XV, fig. 9 exhibits an enlarged drawing of the lobes and saddles of the smaller specimen figured in this plate. The siphonal lobe is wide, and ornamented with four denticles on each of its sides; the siphonal saddle is narrow and deep, and terminates in seven branched festoons; the principal lateral lobe, much larger than the siphonal, is symmetrical in figure, and its sides are ornamented with long denticles; the lateral saddle is as large as the principal lateral lobe, and ends in five festoons; the second lateral lobe is small, narrow, and turned obliquely inwards; the lower lateral saddle is proportionately small, and there are two small auxiliary lobes with corresponding saddles of a like size.

Affinities and Differences.—*Aeg. Belcheri*, Simp., closely resembles *Aeg. intermedium*, Portl. (Pl. XV, figs. 5, 6), in the form of the ribs, their length, curve, and obliquity. *A. Belcheri* wants, however, the fine elevated lines developed between the ribs near the

outer margin, and which pass over the siphonal area in a series of arched lines, their convexity being always directed towards the aperture in *Aeg. intermedium* (figs. 4, 5, 6).

Locality and Stratigraphical Position.—The two specimens I have figured were collected from the Lower-Lias zone of *Aeg. planorbis*, North Cliff, at Robin Hood's Bay. Mr. Blake notes this species under the name of *A. Johnstoni* from Coatham Marsh, and from the zone of *Aeg. angulatum*, Cliff, Leigh Dam, Scar, Eston Pit, Yorkshire. I have not found this species in any of the collections of Lias fossils in Gloucestershire.

Aegoceras intermedium, *Portlock*. Pl. XV, figs. 3—6.

Ammonites intermedius, *Portlock*. Geology of Londonderry, p. 136, fig. 17, 1843.
— — *Morris*. Catal. British Fossils, p. 292, 2nd ed., 1854.

Shell discoidal, compressed; whorls narrow, numerous, seven to eight exposed and slightly involute, flattened on the sides and rounded on the outer margin; ribs acute, straight, or slightly bent, enlarged at the outer margin, where they bend round and disappear from the rounded siphonal area; shell with delicate striæ, which bend forward and meet over the front.

Dimensions.—Diameter 70 millimètres; width of umbilicus 42 millimètres; height of the last whorl at aperture 12 millimètres; width of ditto 12 millimètres.

Description.—This Ammonite was first figured by General Portlock[1] in his valuable and exhaustive report, where it is thus described:—"Section oval, the axis in the plane of the larger whorls being about one-fourth longer than the transverse axis; ribs not extending to the suture on the inside nor over the front on the outside. When the shell is preserved there are very delicate, almost obsolete striæ, which bend forward and meet over the front. The front itself to the eye is quite smooth, but occasionally some irregularity may be discovered by the finger. Ribs are visible almost at the centre, and are sharper and proportionately longer in the inner whorls; occasionally, also, they are slightly bent. This species differs from *A. communis* in not having forked ribs; from *A. planicosta*, in not having the ribs sharply bevelled over the front, though in some specimens traces of a continuation of obsolete ribs over the front may be observed, probably constituting another intermediate variety; from *A. Conybearii* in not having a keel; and from *A. Johnstonii*, to which it closely approximates, in having the ribs closer together and proportionately longer, though in this latter respect it may be observed that, Sowerby's description having been drawn up from a flattened specimen, the breadth of the volution will necessarily appear greater in proportion to the ribs than in the natural condition. The foliaceous septa occupy the space between two ribs, and are extended in broad digitate lobes over the front.

[1] 'Report on the Geology of Londonderry, pp. 136—8, fig. 17, 1843.

"In one specimen the foliaceous septa are distinct; they form a succession of sinuous lobes, augmenting in breadth from the interior to the exterior of the whorl. In some specimens the mode of petrifaction appears to have been curious: in one, for example, an outer whorl is at one end filled by the grey gritty limestone of the surrounding rock; whilst at the other, by the section, it appears half occupied by the limestone and half by white calcareous spar; and again, an inner whorl is entirely occupied by the spar. Ballintoy: indurated shale of trap dike.—This specimen held to the light shows the traces of obsolete ribs or striæ over the front, apparently three between each pair. Glenaven, Cairncastle, Tickmacrevan: calcareous or gritty grey limestone, same as Ballintoy. Where the shell is perfect the front is quite smooth. In the inner whorls the depth is equal to the width, and in the cast the ribs, on coming to the front, where they appear slightly curved, vanish away without visibly passing over, though occasionally there is a trace of such passage sufficient to become perceptible to the finger, or, under a strong light, to the eye. As the whorls augment the breadth increases more in proportion than the depth, and the ribs become comparatively less until at length they have exactly the position of those of *A. Johnstoni*. Ballygalley Head: there appear to be two varieties of this species; the ribs of one being more distant from each other than those of the other, and its section rounder; the form of the septa is the same. Island Magee, Gobbin's Head: same rock, but with sparry fragments, resembling, therefore, the Aghanloo bed, which contains the *A. Sampsoni;* one specimen strongly exhibiting the character of *A. Johnstoni*. Another beautiful mode of petrifaction is exhibited by one of the specimens. The inner whorls are entirely filled with white calcareous spar; but the outer whorl is empty in the centre, the circumference being lined with spar, for about ·1 of an inch, from which project towards the centre numerous acute crystals, the spaces between their opposite points being unequal, according as the process of filling up has more or less advanced."

Affinities and Differences.—I have figured two examples of this Ammonite belonging to the Museum of the Irish Geological Survey, and kindly lent by my old friend, Professor Hull, F.R.S. The specimen (fig. 5) was General Portlock's type specimen. The affinities between this species with *Aeg. Belcheri*, and both with *Aeg. Johnstoni*, are so numerous, and the differences so few, that I am inclined to group them both along with the latter form until better specimens are discovered for a comparison of the species.

AEGOCERAS LAQUEOLUS,[1] *Schloenbach.* Pl. XV, figs. 1, 2, 10—12; Pl. XVI, figs. 1, 2.

AMMONITES LAQUEOLUS, *Schloenbach.* Beitr. Palä., p. 152, pl. xxvi, fig. 1, 1865.

[1] On the explanation of Pl. xv, figs. 1 and 2 are termed *A. Liassicum*, figs. 10—12, *A. tortile;* on Pl. xvi, figs. 1 and 2, are termed *A. Liassicum.* See Synonyms, p. 316.

AMMONITES LIASSICUS, *d'Orbigny*. Pal. franç., T. Jurass., t. i, p. 199, pl. xlviii.
— TORTILIS, — Ibid., t. i, p. 201, pl. xlix.

Diagnosis.—Shell discoidal, depressed; whorls from six to eight, vertically flattened or rounded and slightly involute; umbilicus wide, and spire fully exposed; the convex sides ornamented with from forty to fifty prominent oblique ribs all directed towards the aperture, larger near the umbilical, and diminishing towards the outer margin; siphonal area broad, sometimes marked with slight elevations of obsolete ribs. Lobes and saddles well developed, lobe-line very sinuous.

Dimensions: large specimen (figured Pl. XVI)—transverse diameter 175 millimètres; width of the umbilicus 120 millimètres; height of the aperture 30 millimètres; width of ditto 36 millimètres.

Smaller specimen (figured Pl. XV, figs. 10—12)—transverse diameter 100 millimètres; width of the umbilicus 68 millimètres; height of aperture 16 millimètres; width of ditto 20 millimètres.

Description.—This interesting Ammonite belongs to the group PSILONOTI in the zone of *Angulatum*, from whence I collected several fragments in the Harbury cutting of the Great Western Railway, near Southam, Warwickshire, and which I found to be nearly identical with a specimen sent to me by Monsieur Etallon, from the Lower Lias of France, as a type of *A. tortilis*, d'Orbigny. Some time afterwards I obtained the large specimen figured in Pl. XVI, and which resembled some specimens, about the same size, I saw in the d'Orbigny Collection at the Jardin des Plantes, Paris, and labelled *A. Liassicus*. As neither of my determinations were quite satisfactory, I have constantly been in quest of other figures, and now I find that all my specimens agree very closely with the *Ammonites laqueolus*, Schlönbach, carefully figured in his valuable 'Beitrage zur Paläontologie der Jura und Kreide-Formation in Nordwestlichen Deutschland,' from a specimen collected by Herr Beckmann from the *Angulatum*-beds of Salzdahlum. In consequence of this species being so extremely evolute, it is almost always found in fragments; one of these I have figured (Pl. XV, fig. 1) from a specimen collected in the *Angulatum*-zone in the Trent Valley, Lincolnshire, by the Rev. J. E. Cross, F.G.S.; and I have seen fragments in the British Museum, collected near Horfield by Bristol, where it is called *A. Johnstoni*.

This Ammonite (Pl. XV, fig. 10) is extremely discoidal; the whorls are numerous, very slightly involute, and well exposed. All the specimens I have seen want the centre, so that the number of whorls is uncertain; in Professor Schlönbach's figure of a complete specimen there are seven. They are well rounded, rather convex on the sides, and a little depressed at both margins (figs. 2 and 10), and in some specimens very much so, as in the Harbury specimen (fig. 2) and in the large specimen from Redcar (Pl. XVI). The convex sides of the whorls are ornamented with from fifty-five to sixty ribs, which are sharp and prominent, and all bend obliquely forwards towards the aperture; they are larger and more prominent near the umbilical margin (Pl. XV, figs. 2—10), and become smaller near the outer margin, where they disappear.

The siphonal area (Pl. XV, figs. 11 and 12) is rounded and smooth; this is very well shown in the fine drawing of this region in Pl. XVI, fig. 2; but in some specimens there are feeble indications of elevations resembling obsolete ribs, and in others such marks are absent.

The whorls are almost entirely evolute, the outer simply resting on the penultimate whorl without embracing it (see Pl. XV, figs. 1, 2, 10, and Pl. XVI, fig. 1).

The aperture is transversely oblong or subrotund, owing to the greater or less convexity of the sides of the whorls. None of the specimens I have seen enable me to estimate the approximate length of the body-chamber. One of my fragments, however, from Harbury (fig. 2), exhibits well the very sinuous lobe-line this species possesses, and which is now described for the first time.

The siphonal lobe (Pl. XV, fig. 11) is small, with three digitations on each side and a terminal bifid point. The siphonal saddle is large, with four lateral and three terminal festoons; the principal lateral lobe is large and oblique with two long lateral and a trifidal terminal digitation; the lateral saddle is as large as the principal lobe, and its sides have six lateral and one small terminal festoon; the lower lateral lobe is small and oblique, with four lateral and one terminal digit; the two auxiliary lobes are likewise oblique, the largest has four and the smallest a single festoon, so that the lobe-line of this form is extremely sinuous, as is well shown in the very good enlarged fig. 9, which I have carefully compared with the specimen (fig. 11).

Affinities and Differences.—This species has been often mistaken for *A. Johnstonii*, which it very much resembles. It differs from that form in having a wider and broader siphonal area, and is less uniformly round, and less angular than that form; this is very evident when we compare (Pl. XV, figs. 4 and 6) *Aeg. intermedium* with (figs. 11 and 12) *Aeg. laqueolus*.

The stronger and thicker ribs, as well as the wider interspace between them, serve to distinguish *Aeg. laqueolus*, Schlönb., from *Aeg. laqueus*, Quenst., to which, in other respects, it is nearly related. Probably when a greater number of specimens of *A. laqueus*, Quenst., are discovered, *Aeg. laqueolus*, Schlönb., may prove to be only a variety of the older species, which is remarkable for being extremely evolute, with a round aperture, having the ribs small, delicate, and numerous, and the body-chamber occupying an entire whorl in length.

It resembles *Aeg. tortile*, d'Orbig.; the specimen figured in Pl. XV, fig. 10, having been sent to me as a representative of that species. It differs, however, in some respects from *Aeg. tortile*, in having a rounder and much broader siphonal area, more oblique ribs, with a more complex lobe-line than the one traced from *Aeg. tortile*.

Locality and Stratigraphical Position.—All the specimens I have collected belonged to the zone of *Angulatum*, and this accords with the observations made, apparently with great care, by Prof. Schlönbach. MM. Collenot and Bréon collected *Aeg. laqueus* near Semur in the *Angulatum*-zone.

Second Section.—Angulati.

Aegoceras angulatum, *Schlotheim.* Pl. XIV, figs. 5, 6; Pl. XVII,[1] figs. 1—6.

Ammonites angulatus, *Schloth.* Petrefactenkunde, p. 70, 1822.
— Redcarensis, *Young & Bird.* Geol. Surv. Yorksh. Coast, p. 258, pl. xiv, fig. 13, 1828.
— anguliferus, *Phillips.* Geol. of the Yorkshire Coast, p. 192, vol. i, tab. 13, fig. 19, 1829.
— colubratus, *Zieten.* Verstein. Würtembergs, tab. 3, fig. 1, p. 3, 1830.
— angulatus, *Von Buch.* Ueber Ammoniten, p. 12, 1832.
— Redcarensis, *Simpson.* Monograph on Ammonites of the Yorkshire Lias, p. 55, 1843.
— angulatus, *Quenstedt.* Cephalopoden, p. 74, pl. iv, fig. 2, 1846—9.
— — *Quenstedt.* Petrefactenkunde, p. 354, tab. 27, fig. 7, 1852.
— — *Quenstedt.* Der Jura, p. 43, tab. 3, fig. 1, 1858.
— — *Chapuis et Dewalque.* Fossiles Terr. Second. Luxembourg, p. 36, pl. iv, fig. 1, 1853.
— — *Oppel.* Juraformation, p. 75, 1856.
— Redcarensis, *Simpson.* Fossils Yorkshire Lias, p. 100, 1855.
Aegoceras angulatum, *Tate & Blake.* Yorkshire Lias, p. 271, 1876.

Diagnosis.—Young shell compressed; whorls involute, half enveloped; sides with twenty-six to thirty, sharp, simple, flexed ribs, which commence at the umbilical margin, pass round the outer border, and terminate abruptly in a furrow in the centre of the siphonal area, or in a smooth truncated surface.

Adult shell, several inches in diameter, compressed; whorls flattened, sloping towards the outer margin; sides smooth, with long, faint, biflexed ribs, and shorter and more marked costæ near the border; area narrow, round, smooth; aperture compressed.

Dimensions.—One of my largest specimens from Lyme Regis measures 180 millimètres in diameter. Height of the last whorl near the mouth 65 millimètres; width 40 millimètres. Whorls one-half covered by the involution of the spire.

Description.—Like many other Ammonites, this species must be studied at different stages of growth, if we wish to understand its true characters. Up to about the diameter of an inch the whorls have from twenty-five to thirty sharp simple ribs, which terminate abruptly and form a marked angle on the back—hence the origin of the specific name; at a later period the ribs divide, become less distinct, and the angle on the back disappears; in advanced age the sides are smooth, the siphonal area is narrow, and without ribs.

[1] See pages 322 and 323.

Septa symmetrical (Pl. XVII, fig. 1), divided into five lobes and six saddles, formed of unequal parts; the siphonal lobe much shorter and broader than the principal lateral lobe, divided half its length by the median line into two parts, it is formed of two or three short branches on each side, and has a terminal trifid digit; the siphonal saddle is much larger than the principal lateral lobe, and terminates in three festoons, which divide into folioles; the principal lateral lobe has four small lateral digitations, and a terminal digit, which divides into three or four branches; the lateral saddle, about as large as the principal lateral lobe, terminates in one central and two lateral festoons, the former with four, the latter with three, smaller foliations; the inferior lateral lobe is oblique, with three or four lateral, and a terminal, sometimes bifurcate digit; the three auxiliary lobes are placed very obliquely, and gradually diminish in size as they approach the umbilical angle.

In my large specimen the body-chamber consists of four-fifths of the last whorl, its sides are smooth, and slope towards the outer border, which is round and narrow, without the trace of a keel; there are from thirty to forty long, faint, biflexed ribs, extending from near the umbilical to the outer margin, and shorter intermediate costæ spring from the bifurcation of the former. All the ribs become much more developed as they pass round the siphonal border, before they suddenly disappear.

Affinities and Differences.—This Ammonite belongs to the group Angulati, and to the genus *Aegoceras;* in early life its strong, sharp ribs form an angle on the siphonal area (fig. 6). The marginal furrow which interrupts them (fig. 4) likens it to some Gault species; but adult shells can scarcely be mistaken for any other form associated with them in the Lower Lias (figs. 4—6).

This Ammonite presents many varieties of form during different stages of growth, which have been mistaken for distinct species; it is now ascertained that *Aegoceras Moreanum*, and *Aeg. Leigneletii*, d'Orbigny, are different varieties of *Aeg. angulatum*.

Locality and Stratigraphical Position.—I collected this Ammonite between Charmouth and Lyme Regis, in a dark shale below the grey concretionary limestone with a mamillated surface, which forms the base of the *Bucklandi*-beds, and in the same stratum south-west of the Cob; the zone which it characterises is of no great thickness in Dorsetshire. This Ammonite is considered one of the rarest found on that coast. In Gloucestershire I have collected small ribbed specimens from the lowest shales of the Fretherne section on the banks of the Severn, and it has likewise been found at Aust Cliff. In Warwickshire some fine specimens were obtained from the Harbury cutting of the Great Western Railway, near Southam, and many good fragments are still to be found on the spoil banks of that line. In Yorkshire it is found only in the lowest beds of Lias at Redcar, where it is very rare, and known to local collectors as *Am. Redcarensis*. It is found in the same zone of Lower Lias near Portrush, on the north coast of Ireland.

The varieties of this species figured by d'Orbigny were collected in France from the lowest beds of the Lias with *Gryphæa incurva*, Sow.; at Pont-Auber, near Avallon (Yonne), and Champlong, near Semur (Côte-d'Or): at Jamoigne (Luxembourg); and in several places in Germany near Balingen, Degerloch, Echterdingen, Vaihingen, Stuttgart, and other localites. It everywhere characterises beds which are interposed between the *Planorbis*- and the *Bucklandi*-series.

AEGOCERAS CATENATUM, *Sowerby*. Pl. XIX, figs. 5—7.

AMMONITES CATENATUS, *Sowerby*. De la Beche, Geological Manual, 3rd ed., p. 334, fig. 74, 1833.
— TRAPEZOIDALIS, *Sowerby*. Ibid., p. 334, fig. 75.
— CATENATUS *d'Orbigny*. Pal. Franç., Terr. Jurass., vol. i, p. 301, pl. xciv, 1842.

Diagnosis.—Shell discoidal, compressed; whorls depressed, one third involute, and all exposed; sides flattened, with twenty-eight to thirty strong, simple ribs, which are twice arched, elevated, and enlarged as they approach the outer margin, and interrupted in the siphonal area, which is smooth or crenulated; aperture oblong, compressed, notched by the preceding whorl.

Dimensions.—Diameter 53 millimètres; width of the umbilicus 23 millimètres; height of the last whorl at aperture 18 millimètres; thickness 13 millimètres.

Description.—This rare Ammonite is found in the Lower Lias at Barrow-on-Soar, and is seldom seen in any of the metropolitan Museums. It is a very well marked form, and a fair example of the *Angulati* group. The species was first found by my old friend the late Sir Henry De la Beche, along with other Lias fossils in limestone at La Spezia, Italy, and is recorded in the following passage:—"As far, therefore, as the evidence of the *Ammonites* and *Orthoceratites* extends, we may refer the limestone of La Spezia either to the Lias or the Coal Measures. There will be observed a curious correspondence in the organic character of the rocks of the Savoy and French Alps above noticed, and considered as Lias by M. Elie de Beaumont, with that of the limestones of La Spezia. In the former Coal Measure plants are found with *Belemnites;* in the latter Coal Measure *Ammonites* also occur with *Belemnites*.

"The organic character of the Oolitic group in the Alps is far from being well ascertained, and the undescribed organic remains found in the same series of the South of France are exceedingly numerous, so that it may be possible to discover some of the La Spezia Ammonites in both situations; and the organic remains of the South-east of France, the Alps, and La Spezia, may hereafter mutually assist in determining the relative ages of the rocks in which they are discovered."[1]

[1] 'Geol. Manual,' 3rd edition, p. 334, 1833.

I have quoted this remarkable passage from Sir Henry De la Beche's 'Manual,' as it shows how the principles of palæontology were understood in 1833 by one of the greatest masters of geological science in the English or any other school. Had the true value of Ammonites been known in his day, and the limits of the distribution of their species in time and space been understood, the finding of a true Lias Ammonite would have settled the question of the age of the limestone at La Spezia in which it was discovered in spite of mistaking Belemnite phragmacones for Orthoceratites.

The shell of *Aegoceras catenatum* is compressed; the sides are ornamented with twenty-eight simple, sharp, very prominent ribs, arched upwards, backwards, and forwards, becoming thicker as they approach the margin, and forming an arch over the area, which is rather conspicuous in the figured specimen, whilst in others it is almost smooth. The spine is formed of five convex whorls nearly one third involute, and all seen in the umbilicus. The aperture is a compressed oval, cut out inwards by the turn of the spire. The septa (fig. 7) are symmetrically divided on each side into three lobes formed of unequal parts. The siphonal lobe is smaller than the principal lateral, and terminates in three digitations; the siphonal saddle is wide, and ends in three cells; the principal lateral lobe is long, with three digits on each side and a terminal seventh having a trifid process; the lateral saddle is as large as the principal lateral lobe, and ends in two cells; the lower lateral lobe is shorter than the principal, and has three digits on one side, rudiments of digits on the other, and ends in three points; the first auxiliary lobe is oblique, with three inner digits, and the second auxiliary is rudimentary.

Affinities and Differences.—This species very much resembles some of the forms of *Aeg. angulatum*; it differs, however, in the narrowness of the siphonal area, in retaining its ribs entire up to an advanced age, and having a different lobe-line to that form.

Locality and Stratigraphical Position.—The specimens I possess of this Ammonite I owe to the kindness of Mr. W. J. Harrison, F.G.S., late of the Leicester Museum; they were obtained from the Lower Lias beds at Barrow-on-Soar, and are largely charged with iron-pyrites. I know of no other locality in the British Islands.

Foreign Localities.—Professor d'Orbigny states that this Ammonite was found below the Lower Lias beds with *Gryphæa arcuata* at Pont-Auber, near Avallon, Yonne; Semur, Côte-d'Or; and that young specimens, figured by him in his plate 94 were collected on the Gulf of La Spezia, near Coregna (Italy), thus determining the age of that terrain; he further adds that the so-called *Orthoceratites* of De la Beche, already referred to in my extract as found in the same locality, as well as those from the Lake of Como, were the articulations of the alveoli of *Belemnites*. This observation clears up the difficulty which Sir Henry experienced in determining the age of the limestone at La Spezia.

AEGOCERAS MOREANUM,[1] *d'Orbigny*. Pl. XVII, fig. 1—6.

AMMONITES MOREANUS, *d'Orbigny*. Paléont. Franç., Terr. Jurass., p. 299, pl. xciii, 1842.
— ANGULATUS, *Stur*. Jahrbuch der k. k. geolog. Reich., vol. i, p. 165, 1851.
— MOREANUS, *Studer*. Geologie der Schweitz, vol. ii, p. 30, 1853.
— — *von Hauer*. Jahrbuch geologischen Reichsanstalt, vol. iv, p. 736, 1853.
— — *Martin*. Infra-Lias du Départ. de la Côte-d'Or, p. 38, 1860.
— — *Terquem et Piette*. Lias inf. de l'est de la France, p. 26, 1865.

Diagnosis.—Shell discoidal, compressed; whorls flattened, sides convex, internally smooth and feebly undulated, externally crenulated, with prominent bifurcations of obsolete ribs; siphonal area narrow, smooth in the centre, and costated at the outer margin; aperture compressed, triangular, incised internally by the penultimate whorl, and notched outwardly by the siphonal area; involution one-half the depth of the whorl.

Dimensions.—Transverse diameter 170 millimètres; width of the umbilicus 48 millimètres; height of the last whorl at the aperture 70 millimètres; greatest width of ditto 43 millimètres. In four specimens before me, including the fossil figured, the relative proportions of these parts vary considerably. Professor d'Orbigny's type specimen measured:—Diameter, 75 millimètres; in relation to the diameter the size of the last whorl was $\frac{35}{100}$; involution of the last whorl $\frac{8}{100}$; width of the umbilicus $\frac{43}{100}$; thickness of the last whorl $\frac{19}{100}$.

Description.—This Ammonite has a compressed, discoidal shell, with flattened whorls, the sides of which are slightly convex; on the inner or umbilical half of the whorl they are smooth, and have from thirty to forty curved undulations, representing so many obsolete ribs; near the outer or siphonal margin the folds appear to bifurcate, and develop a number of short, transverse, oblique costæ, more or less prominent in different specimens; the spire is formed of very compressed whorls, which are nearly one half concealed by the volutions of the spire, leaving a narrow umbilicus. The siphonal area is contracted, smooth in the centre, and crenulated at the sides by the development of the short oblique costæ which ornament the outer margin of the shell. The aperture is compressed, and more or less triangular, and varies in the proportional measure of its height in different specimens.

The young shells of this form, up to two to three inches in diameter, are provided with simple bent ribs, which terminate near the outer margin; these ribs become enlarged as they approach the margin, and are sharply bent inwards at the side of the siphonal area, where they disappear, leaving the centre of this space quite smooth.

[1] Considered to be a variety of *Aegoceras angulatum* and named *Aegoceras angulatum* in the explanation of Plate XVII.

The lobe-line is very complicated, the symmetrical septa being divided into five lobes and saddles, all formed of unequal parts. The siphonal lobe is small, and terminates in three short branches, two of which are bifid; the siphonal saddle is much wider than the principal lateral lobe, and forms an arch with three terminal festoons. The principal lateral lobe is large, and has a branched termination in three irregular digits and three small lateral prolongations on each side; the lateral saddle is as wide as the principal lateral lobe, and ends in three irregular-shaped festoons; the lower lateral lobe is narrow and oblique, and ends in three digits; the three auxiliary lobes are placed very oblique, they diminish in size as they approach the umbilicus, and end in a small trifid digit (Pl. XVII, fig. 1).

Affinities and Differences.—This Ammonite very much resembles *Aegoceras angulatum*, but the smoothness of the sides of the whorls, in consequence of the absence of ribs and the development of the short, oblique, crenulated series around the outer margin, with its smooth centre in the siphonal area, and a difference in the dimensions of the lobe-line, induced d'Orbigny to separate it under the name *Moreanus*. I am inclined to consider it only a variety of *angulatum* and not a distinct species. This Ammonite characterises a particular horizon of life very rich in fossils in the Côte-d'Or.

Locality and Stratigraphical Position.—This species is found in a dark grey shale near Charmouth, from whence all my specimens have been obtained. Young forms of *Gryphæa arcuata* make their appearance for the first time in this bed; one of these Oysters has become firmly adherent to the shell I have figured.

Professor d'Orbigny says it characterises the inferior beds of the Lower Lias, which lie below the *Gryphæa arcuata;* the figured specimen was collected at Pont-Aubert near Avallon, Yonne, where it is very rare. M. Martin says this Ammonite distinguishes the zone of *Ammonites Moreanus* in the Department of the Côte-d'Or, and the reader is referred to his classical work on the Infra-Lias of that Department for an admirable account of the rich fauna it contains.

AEGOCERAS CHARMASSEI, *d'Orbigny*. Pl. XX, figs. 1—3.

AMMONITES SULCATUS, *Simpson?* Monogr. of Ammonites, York. Lias, p. 55, 1843.
— CHARMASSEI, *d'Orbigny*. Paléontol. Franç., Terr. Jurass., i, p. 296, pls. xci, xcii, 1844.
— SULCATUS, *Buckman*. Murchison's Geology of Cheltenham, 2nd ed., p. 91, pl. ii, figs. 1—3, 1845.
— ANGULATUS, *Quenstedt*. Die Cephalopoden, p. 262, 1847.
— CHARMASSEI, *Kudernatsch*. Jahrbuch der k. k. geologischen Reichsanstalt ii Heft, p. 173, 1851.
— — *Savi e Meneghini*. Considerazioni sulla Geologia della Toscana, p. 104, 1851.
— — *Meneghini*. Nuovi fossili Toscani, p. 12, 1853.

AMMONITES CHARMASSEI, *Studer*. Geologie der Schweitz, vol. ii, pp. 30, 34, 1853.
— ANTIQUATUS, *Simpson?* Fossils of the Yorkshire Lias, p. 36, 1855.
— CHARMASSEI, *Von Hauer*. Cephalopoden Lias N.-O. Alpen, p. 49, pl. xiv, figs. 1—3, 1856.
— — *Dumortier*. Dépôts Jurass. du Bassin du Rhône, II, p. 29, pl. xvii, figs. 1—4, 1867.
AEGOCERAS — *Tate and Blake*. Yorkshire Lias, p. 272, 1876.

Diagnosis.—Shell discoidal, depressed; whorls compressed, slightly convex, one half involute, sides ornamented with numerous unequal ribs, variable as to number, in general thirty, bifurcate about the middle of the whorl and terminating at the margin in a blunt thickening. Siphonal area narrow, subcarinate, and furrowed in the middle, sides carinated with the two rows of blunt terminal ribs; aperture high, narrow, sagittate; umbilicus moderately open; lobe-line very sinuous, forming six lobes and numerous saddles; number of ribs at umbilical margin thirty, at siphonal margin sixty.

Dimensions.—Transverse diameter of figured specimen 170 millimètres; width of the umbilicus 45 millimètres; height of the last whorl at aperture 80 millimètres; greatest width of ditto 40 millimètres.

Prof. d'Orbigny's type specimen measured:—Transverse diameter, 235 millimètres. The relations to the diameter in an adult were—height of the last whorl $\frac{50}{100}$; involution of the last whorl $\frac{9}{100}$; width of the umbilicus $\frac{20}{100}$; thickness of the last whorl $\frac{11}{100}$. In a young shell the width of the last whorl $\frac{41}{100}$; width of umbilicus $\frac{29}{100}$; thickness of the last whorl $\frac{25}{100}$.

Prof. Von Hauer has given the dimensions of a very fine specimen. The transverse diameter was 6 inches = 154 millimètres; the height of the last whorl $\frac{41}{100}$ of the diameter; width of last whorl $\frac{20}{100}$; the width of the umbilicus $\frac{31}{100}$.

M. Eug. Dumortier, 'Dépôts Jurassiques,' vol. ii, p. 29, has given the dimensions of three fine specimens with their test, belonging to M. Ed. Pellat's collection, and all obtained from the same quarry of Lower Lias at Drevain, Saône-et-Loire.

PARTS MEASURED.	No. 1.	No. 2.	No. 3.
Diameter	20½ millim.	76 millim.	225 millim.
Height of the last whorl in relation to the diameter	$\frac{36}{100}$	45 „	47 „
Thickness of the last whorl	31 millim.	25 „	21 „
Umbilicus, width of	34 „	23 „	22 „
Number of ribs, outer margin	44 „	52 „	78 „

Description.—The form and structure of this Ammonite were very variable in the different phases of its growth. In youth, and when it has a diameter of eighty milli-

mètres, it is moderately compressed, the whorls are nearly one half involute, and their convex sides near the umbilical margin are covered with twenty well-marked ribs, which bifurcate near the middle of their height, and enlarge as they advance toward the margin, where they terminate in thick blunt knobs. The siphonal area is narrow and smooth, sometimes concave in the middle, and ribbed at the sides by the enlarged terminations of the costæ. The spire is composed of several moderately thick whorls, which are convex on the sides and bevelled away near the margin. The aperture is elongated, narrow, and sagittate.

In middle age, which is fairly well represented by the fine specimen from Lyme Regis, figured in Pl. XX, we observe all the characters which distinguished its earlier life very well developed in this specimen. The number of primary ribs on the last whorl at the umbilical margin now amount to thirty, and the secondary ribs arising from the bifurcation of the primaries amount to sixty. The thickening of the secondary ribs as they approach the margin, and their final termination in a rounded knob-like eminence, are very characteristic of this species.

In old age this Ammonite attains a considerable magnitude. I have one specimen which measures 320 millimètres in diameter, and yet wants a considerable portion of the body-chamber. The shell is much compressed, and the relative proportions of its different parts are much changed. The ribs have gradually become much smaller and less prominent until they have finally disappeared, and left the sides of the fossil quite smooth. The umbilicus is proportionately much less in width to the total diameter of the shell; the last whorl is much higher, and not nearly so wide in proportion; the siphonal area, from the bevelling away of the deep sides, has become very narrow, and its prominent centre forms quite a carina—in fact, had the student not watched and noted the changes that take place in the growth of this Ammonite, he could not believe, on comparing the young with the old shell, that he was only examining the same species passing through its various morphological phases of evolution.

The lobe-line is extremely tortuous in this species, as shown in Pl. XX, fig. 1, and three large and three small oblique auxiliary lobes, with three large and three small oblique saddles, are shown on the sides of the whorls. The windings of the lobe-lines from adjoining septa are, however, so closely approximated that it is extremely difficult to trace the one line continuously from the siphonal to the columellar lobe. The siphonal lobe is as wide, but not so long, as the principal lateral, and has on each side three large branches with multi-digitate terminations; the siphonal saddle is as wide as the principal lateral, and is deeply divided into three irregular folioles with their sides much festooned; the principal lateral is large and very conspicuous, it has a pyramidal form, with three long branches on its outer, and four on its inner side, and a long terminal multi-digitate process; the lateral saddle resembles the siphonal in size and in the complexity of its ramifications; the lower lateral lobe is very much smaller than the principal, which it resembles much in the style of its digitations; the auxiliary lobes, three or four in

number, diminish in size from without inwards as they approach the columellar suture, and a radial line, drawn from the point of the siphonal lobe inwards to the first auxiliary, cuts the termination of the principal lateral, and leaves all the other portions of the septa much in advance.

Affinities and Differences.—*Aegoceras Charmassei* very much resembles *Aeg. angulatum* in youth and middle age, but in old age the whorls are much higher, and the lobe-line is very different. It resembles *Aeg. catenatum* in youth in its general outline, but still its ribs are bifurcated, whilst those of *Aeg catenatum* are simple. It has certain affinities with *Aeg. Boucaultianum* in the height of its whorls, and in the ribbing of the same. *Aeg. Boucaultianum*, however, has many more small close-set ribs, with a flatter area, tuberculated on the sides, and with a different and more complicated lobe-line than *Aeg. Charmassei*. I know of no other forms with which this beautiful Ammonite has any close relations. The Rev. J. F. Blake, F.G.S.,[1] notes "This appears to me a protean species, whose varieties are extreme . . . There is (α) an inflated variety, whose cross section is a transverse rounded rectangle, with great inflated ribs, and whorls scarcely overlapping, not growing to above two inches in diameter; (β) the ordinary form flatter and larger (six inches); (γ) a far more involute form, with the outer whorl half the diameter, as figured by Dumortier ('Depôts Jurassiques,' part 1, pl. xvii, figs. 1 and 2); (δ) the large adult shell nearly smooth, as figured by d'Orbigny (pl. xcii). The variety α includes the *A. crenularis* of Simpson; variety γ is the *A. Boucaultianus* of d'Orbigny. The Yorkshire specimens have so decided a connection with *Aeg. Charmassei* as to force me to include them under the latter name. More characteristic forms of *A. Boucaultianus* have been found by Mr. Cross in Lincolnshire. The *A. antiquatus* of Simpson is a fragment of the adult shell; while *A. sulcatus* (*A. Leignelettei*, d'Orb.) is the young of the ordinary form. Simpson's name, *A. sulcatus*, would have preference of *A. Charmassei*, by which the species is well known, only fortunately the former name was preoccupied by Lamarck."

Localities and Stratigraphical Position.—This species is found in the zone of *Arietites Bucklandi* at Redcar and Robin Hood's Bay, Yorkshire, and in beds of like age at Charmouth, and Lyme Regis, Dorset, and at Portrush, near Londonderry, on the north coast of Ireland. In France, it is found with *Gryphæa arcuata* in the centre of France, and has been collected in the Lias quarries at Avallon, Yonne; near Semur, and Clomot, Côte-d'Or; and at Drevain, Saône-et-Loire.

In South Germany it is found in the Lower Lias between the zone of *A. planorbis* and that of *A. Bucklandi* at Ostdor by Balingen, near Aich, Echterdingen, Degerloch, Vaihingen, Bebenhausen, Bemflingen, Göppingen, Metzingen, Kaltenthal, near Stuttgart, Würtemberg.

[1] 'Yorkshire Lias,' p. 272.

AEGOCERAS BOUCAULTIANUM, *d'Orbigny*. Pl. XVIII, figs. 1—4.

AMMONITES BOUCAULTIANUS, *d'Orbigny*. Terr. Jurass., vol. i, p. 294, pls. xc, xcvii, 1842.
— — *Dumortier*. Dépôts Jurassiques du Bassin du Rhône, vol. ii, figs. 3—5, p. 138, pl. xxxix, figs. 1, 2, 1867.
— — *Collenot*. Géologique de l'Auxois, p. 237, 1873.

Diagnosis.—Shell large, discoidal, and much compressed ; whorls slightly convex and largely involute; umbilicus very narrow, inner whorls nearly all concealed and covered with a number of small biflexed ribs, unequally bifurcate near the umbilical margin, and terminating at the outer margin in a series of small bead-like tubercles; siphonal area narrow, and convex, sides with the rows of tubercles derived from the terminations of the small costal lines; aperture narrowly oblong; lobe-line extremely tortuous, with a great development of the siphonal and principal lateral lobes.

Dimensions. *Figured specimen* (fig. 1) :—Diameter 155 millimètres; height of the last whorl near the aperture 90 millimètres; width of the umbilicus 24 millimètres.

Professor d'Orbigny's specimen :—Diameter 120 millimètres. Proportional measurements in relation to the diameter :—width of the last whorl $\frac{18}{100}$; involution of the last whorl $\frac{14}{100}$; width of the umbilicus $\frac{11}{100}$; thickness of the last whorl $\frac{28}{100}$.

Description.—The shell of this rare Ammonite is discoidal and much compressed. The whorls are slightly convex and ornamented with numerous narrow ribs, which, commencing at the umbilical margin, first bend backwards, then incline forwards, and at about the middle of the whorl bifurcate, then sweeping towards the aperture they terminate at the side of the outer margin in a small tubercle, and, without becoming entirely interrupted, pass across the area to the opposite side (fig. 3). The siphonal area is very narrow, slightly convex, feebly ribbed in the middle, and bounded on each side by a row of tubercles, which are developed on the terminal ends of the ribs (figs. 2 and 3). In the cast the area is rounded, but when the shell is preserved there is a median depression, with rows of lateral tubercles corresponding to the terminations of the ribs (see figs. 2 and 3). The spire is formed of whorls, which largely embrace each other; the last whorl is so extremely involute that it almost completely envelopes the penultimate whorl, and nearly conceals the umbilicus (figs. 1 and 2).

The aperture is narrow, elongated, and much compressed (fig. 3); the lobe-line is extremely tortuous, and d'Orbigny, who had the opportunity of seeing and figuring the septa, has given the following description :—The septa are symmetrical, divided on each side into four very complicated lobes, formed of pairs of parts, and of saddles composed of folioles almost in pairs; the siphonal lobe is as long and almost as wide as the principal lateral lobe, deeply divided into three very ramified and very complicated branches (see Pl. XVIII, fig. 4); the siphonal saddle, wider than the

principal lateral lobe, is formed of two large unequal leaves, of which the internal one is the largest, and both are very much divided; the principal lateral lobe terminates in two large very much ramified branches. D'Orbigny was however unable to follow the others, as shown in his excellent drawing of the lobe-line which I have copied from his work in my fig. 4, Pl. XVIII.

Affinities and Differences.—M. Eug. Dumortier has figured, in his 'Dépôts Jurassiques du Bassin du Rhone,' pl. xxx, figs. 1 and 2, a fragment found at Jambles, Saône-et-Loire, which agrees very well with the specimen I have figured in Pl. XVIII, fig. 1, from the Rev. J. E. Cross's collection; the sides are convex; the siphonal area narrow, and furnished with a round carina, which is absent from the mould.

Professor Quenstedt has figured and described, 'Der Jura,' p. 98, pl. xii, fig. 7, a fragment from his "Beta" limestone of Ofterdingen, under the name *betacalcis*, and this comes from the same horizon as *A. Boucaultianum*. It has many affinities with our large specimen; the crenulated carina appears to separate it from *A. Boucaultianum;* still it must not be forgotten that this is a single unique specimen, and that some of the type specimens in the Semur Museum, with their shell preserved, measuring from twelve to fifteen inches in diameter, show a disposition to a like crenulation on the central portion of the siphonal area, so that I am inclined to think that Quenstedt's fragment, when better specimens are found, may turn out to be a true *A. Boucaultianum*.

Localities and Stratigraphical Position.—The Rev. J. E. Cross, F.G.S., collected his specimen, the only British one I know, from the Upper Bucklandi-beds of the Scunthorpe Ironstone, North-west Lincolnshire. A suite of several very fine specimens has been obtained from the Lower Lias near Semur, Côte-d'Or, and is in the Museum of that town. One noble Ammonite, with its shell preserved, which I measured, was upwards of twelve inches in diameter. Pl. XVIII, figs. 2, 3, represent a specimen reduced one third the natural size, in the collection of Monsieur Boucault of Semur, who collected it at Champlong, near that town. Several important characters of this rare Ammonite are here very well shown. I am indebted to my friend, M. Collenot, of Semur, for two specimens of this Ammonite, which he has kindly sent me to complete my description of the species. The largest specimen is 185 millimètres in diameter, the height of the aperture is 110 millimètres, its width 50 millimètres, and the diameter of the umbilicus 23 millimètres; the twenty-six lateral primary ribs are well seen; at the umbilical margin they bifurcate irregularly at about one third the height of the whorl, and toward the aperture become thickened at the side of the siphonal area and develop a tubercle on each; the centre of the area is narrow and flattened, and the ribs pass from one side to the other (fig. 3). The shell is preserved on a small portion only of a larger specimen, but enough remains to enable me to make out its remarkable structure; the shell is very thin, and bears a delicate sculptured surface, with lines following the flexure of the ribs, as is very well exhibited in Pl. XVIII, figs. 1 and 2; the lines, however, are much more delicate in the specimens sent me by M. Collenot than in those represented in d'Orbigny's

PLATE XXII A.

Zone of Amaltheus oxynotus.

Fig. 1. ARIETITES IMPENDENS, *Young & Bird.* Side view, natural size. Woodwardian Museum, Cambridge.

2. — — — Front view of the same shell.

3. — — — Siphonal area of do. do.

4. — — — Young shell with sharp ribs and sulci.

5. — — — The lobe-line magnified.

6. — COLLENOTTII, *d'Orbigny.* Side view, natural size. Woodwardian Museum, Cambridge.

7. — — — Front view of same shell.

8. — — — Siphonal area of do. do.

9. — — — The lobe-line, highly magnified.

Fig 1
Fig 4
Fig 6

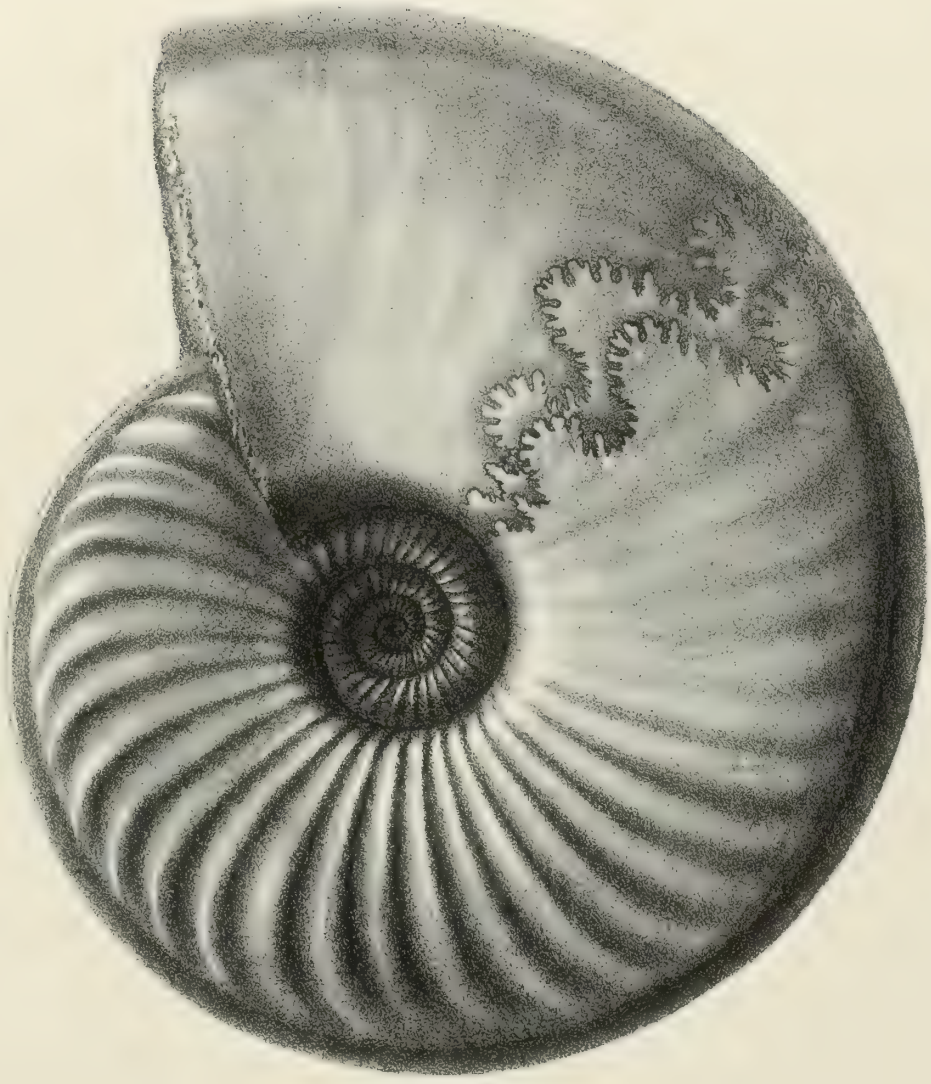
PLATE XXII B.

Zone of Amaltheus oxynotus.

Fig. 1. ARIETITES COLLENOTTII, *d'Orbigny*. Side view, natural size. Woodwardian Museum, Cambridge. The lateral lobes with their numerous digitations, and the saddles with their lobules, are well shown *in sitû* in this specimen, the largest that has been found.

2. — — — Front view of same shell showing the sagittate aperture.

3. — — — Siphonal area, natural size, showing the form of the siphonal lobes filling in the sulci.



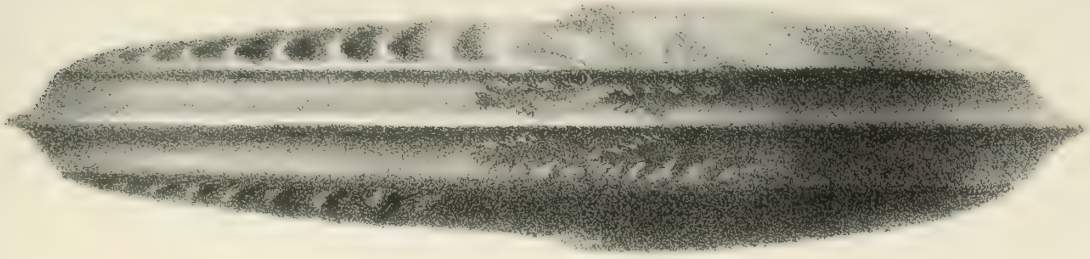
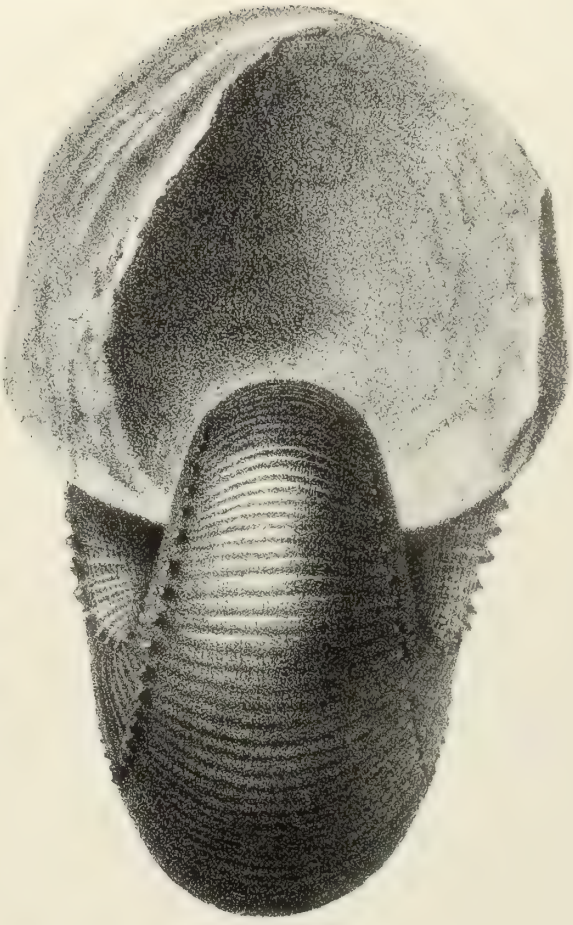
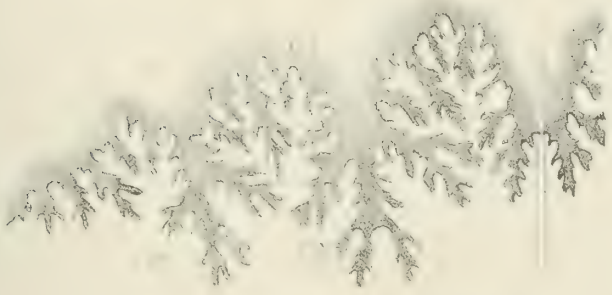


PLATE XLI.

Zone of Aegoceras Henleyi.

Fig. 1. Aegoceras Bechei, *Sowerby*. Side view, natural size. My collection.
2. — — — Front view of the same specimen.
3. — — — Side view of a smaller shell, showing sculpture.
4. — — — Siphonal area of the same fossil.
5. — — — Lobe-line, showing the extremely ramified lobes and saddles of this Ammonite.





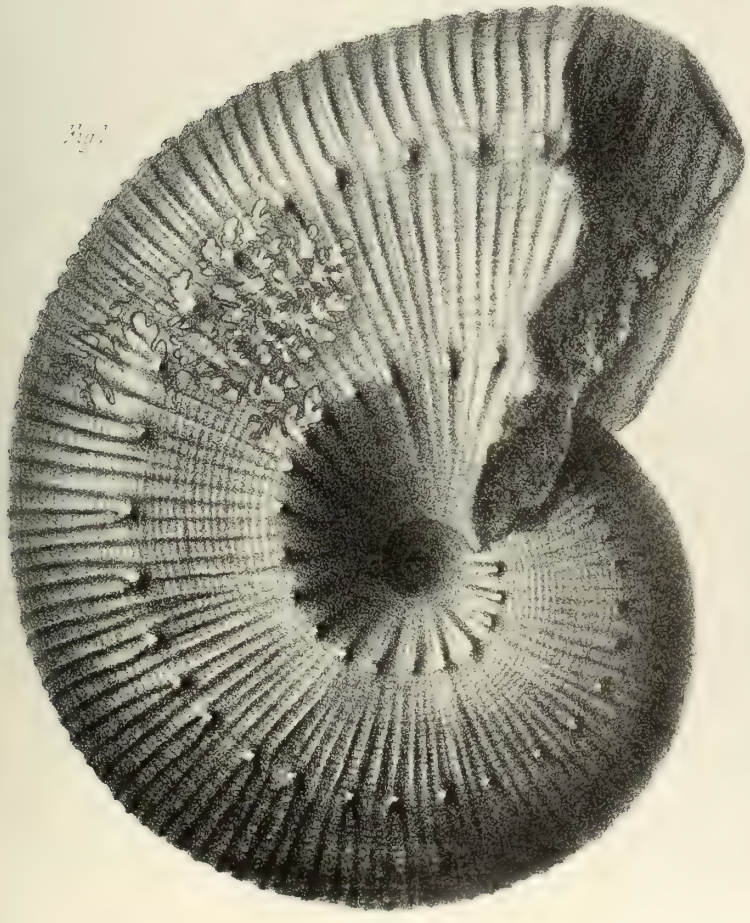
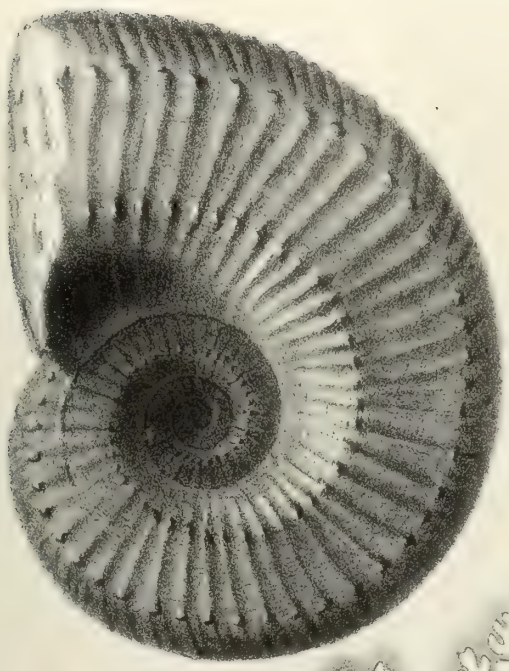
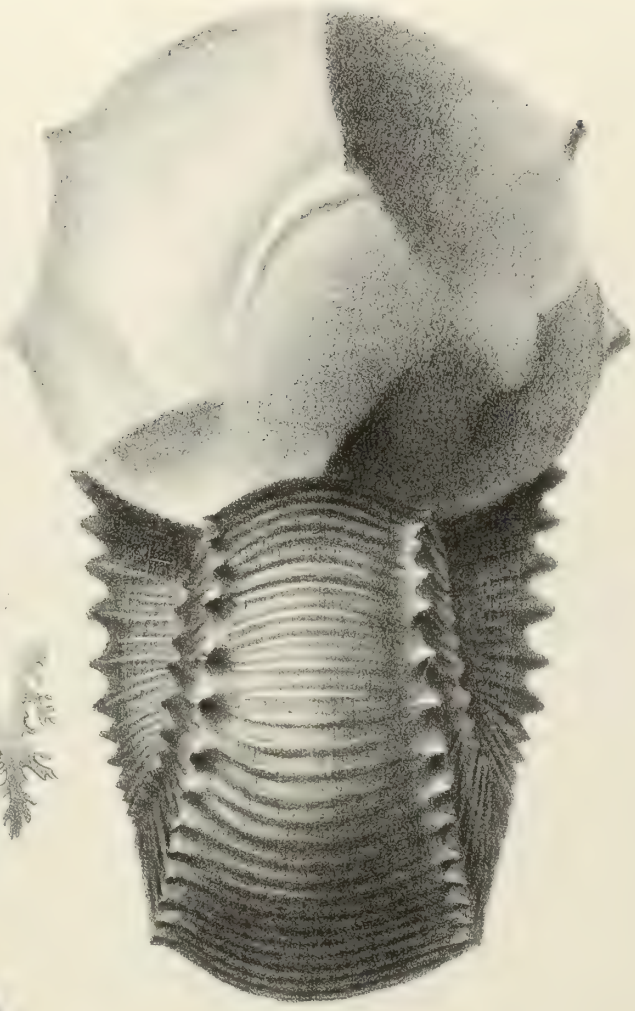


PLATE XLII.

Zone of Aegoceras Henleyi.

Fig. 1. AEGOCERAS STRIATUM, *Reinecke.* Side view, natural size. My collection.
2. — — — Side view of a smaller shell, showing sculpture.
3. — — — Front view of figure 1.
4. — — — Siphonal area of figure 2.
5. — — — Lobe-line, showing the extremely ramified lobes and saddles of this fossil.





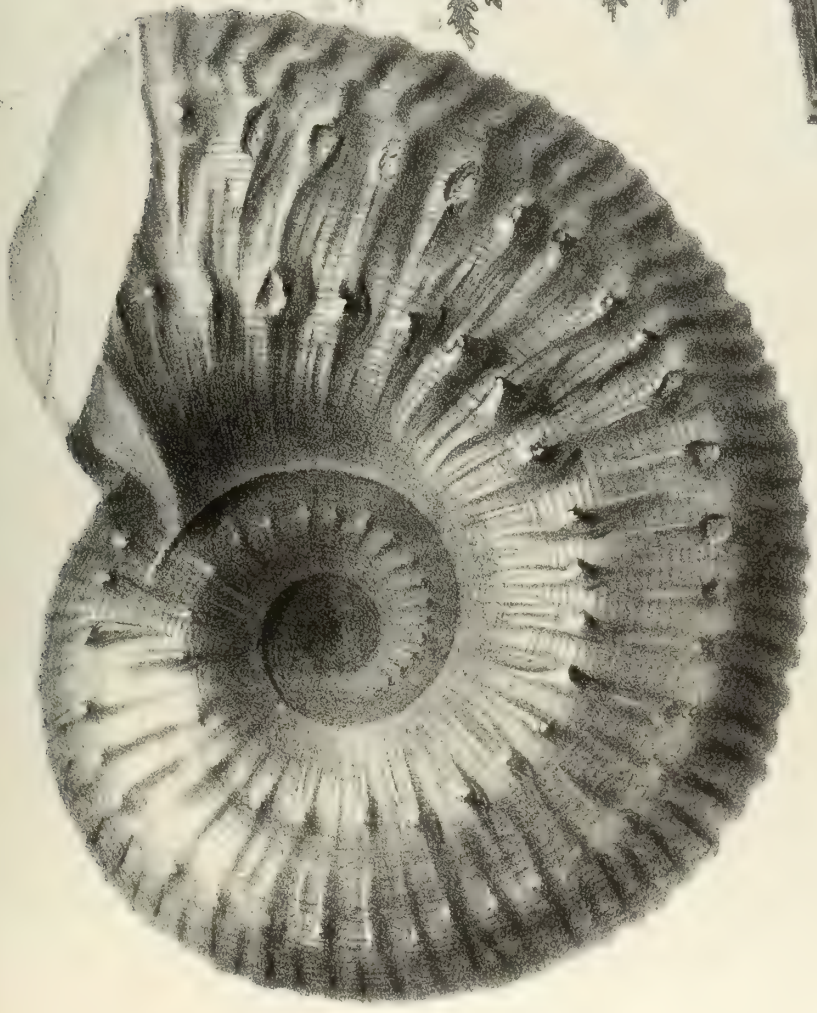


PLATE XLIII.

Zone of Aegoceras Henleyi.

A very fine old shell of AEGOCERAS STRIATUM, *Reinecke*. Collected upwards of thirty years ago near Lyme Regis. Was long in the possession of a local collector, but now belongs to the Museum of the Royal School of Mines, and kindly lent by Mr. Etheridge, F.R.S., for this plate. The figure is of the natural size.

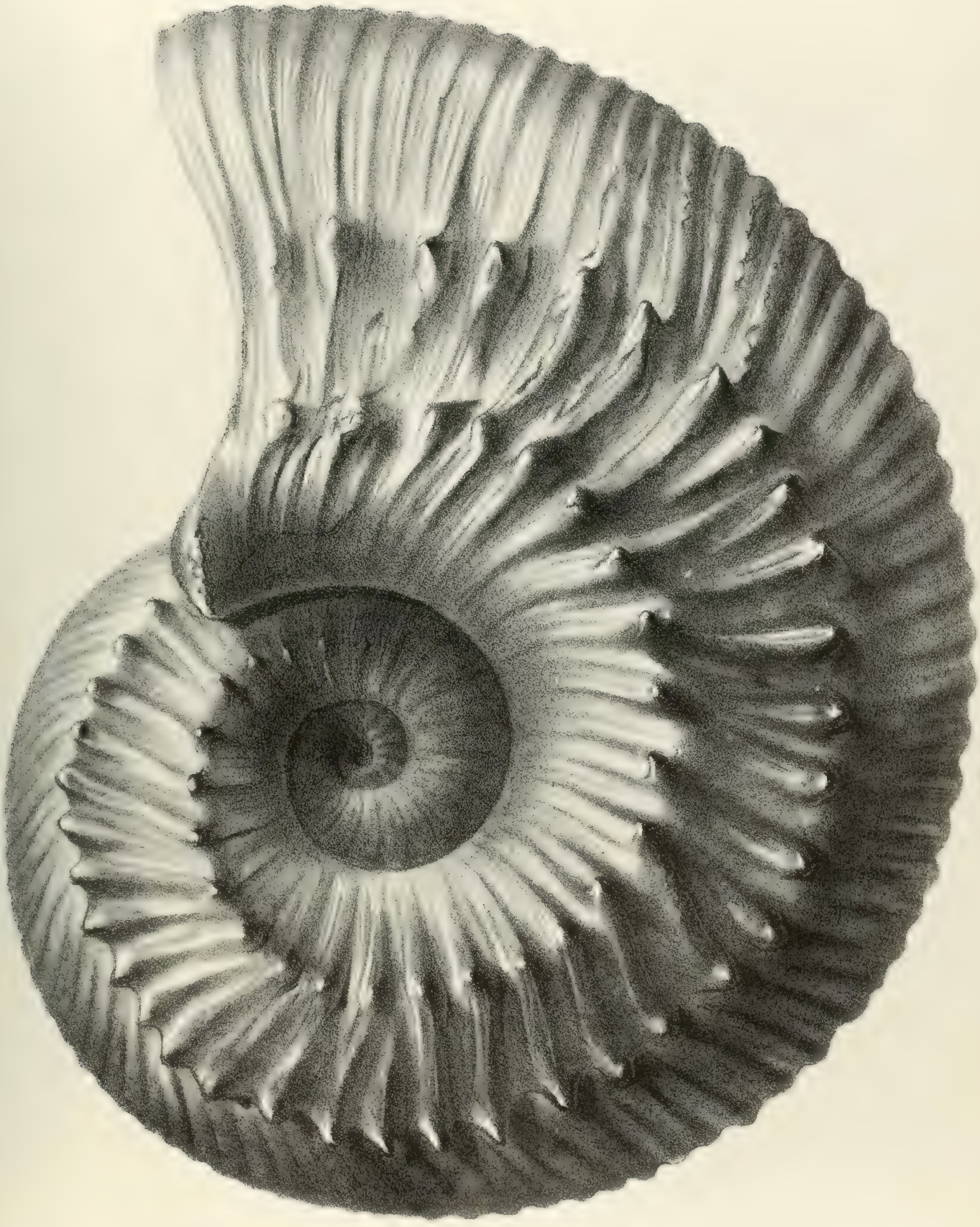


PLATE XLIV.

AMALTHEUS GREENOUGHI, *Sowerby*. One half the natural size. British Museum.

A Gawan del.et lith.

PLATE XLV.

Zone of Amaltheus oxynotus.

Fig. 1. AMALTHEUS GUIBALIANUS, *d'Orbigny*. Side view, young shell, natural size. My collection.

2. — — — Siphonal area of do. do.

3. — — — Front view of a larger fossil showing the shape of the aperture, nat. size.

4. — — — Side view of another example showing the lobes and saddles *in sitû*.

5. — — — Lobe-line showing the lobes and saddles enlarged, from a tracing on the fossil.

6. — — — Front view of a larger specimen showing siphonal area, keel, and terminal costæ.

7. — — — Side view of the same specimen showing the lateral foldings and umbilicus, natural size.

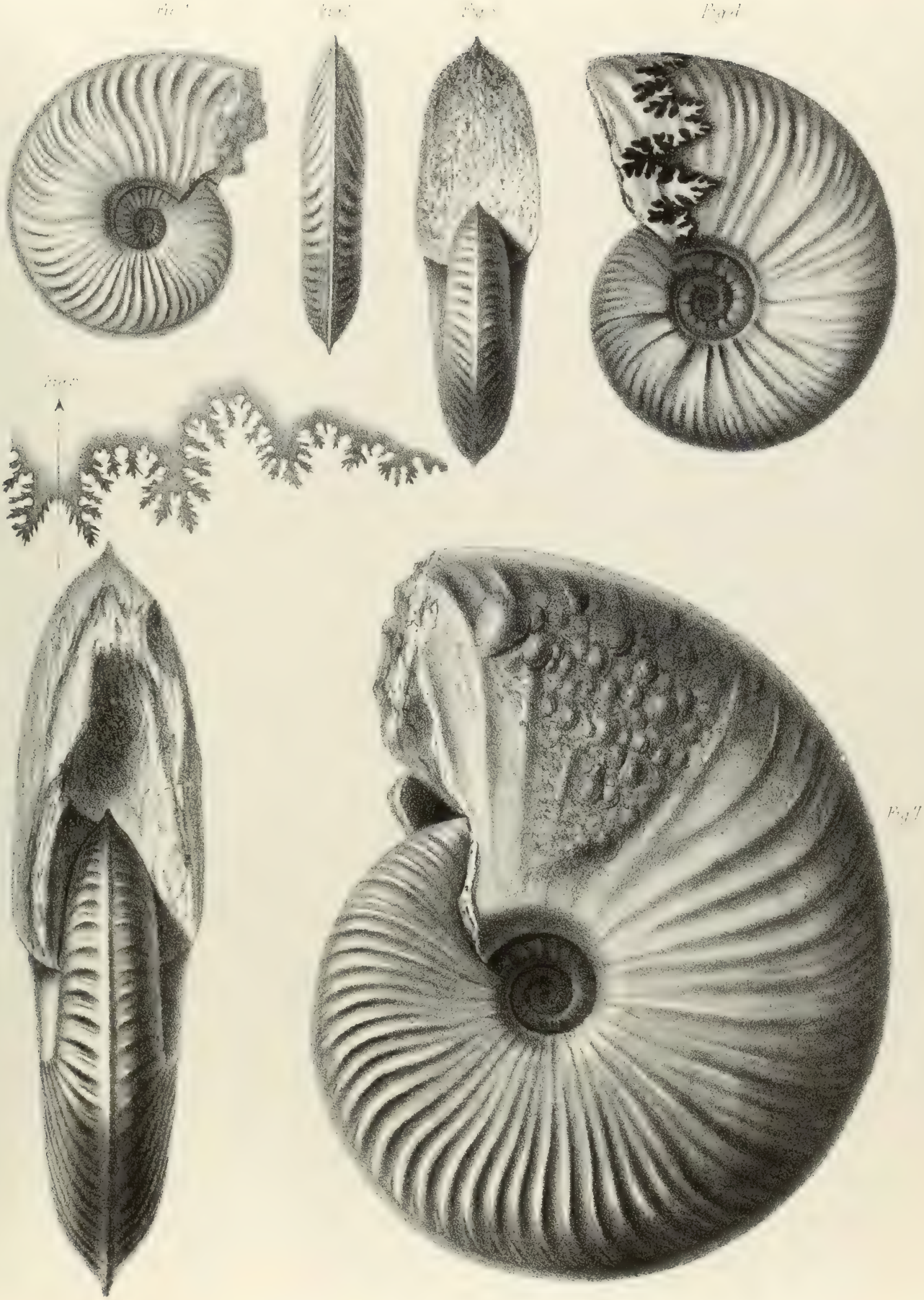


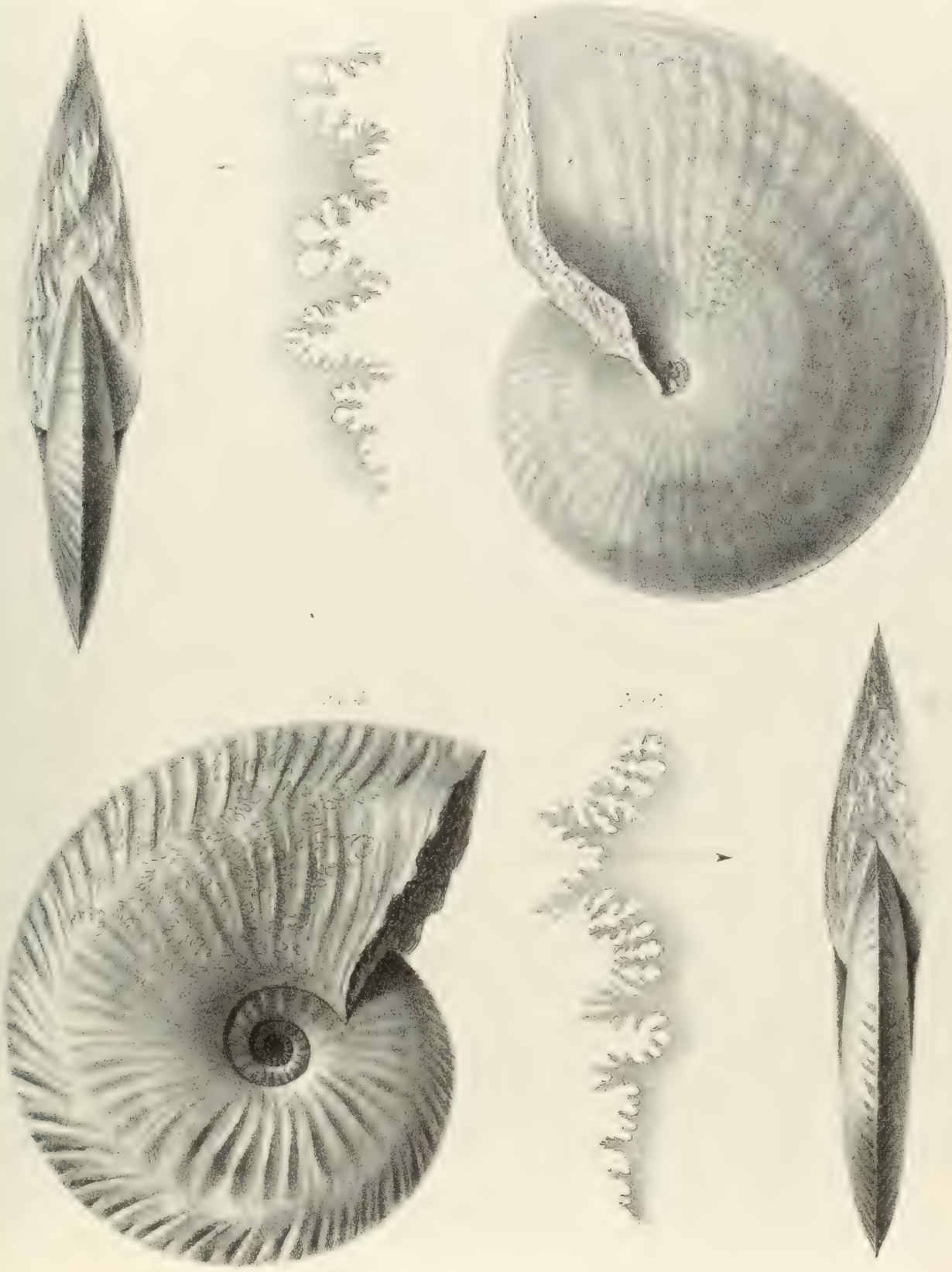
Fig 5

Fig 7

PLATE XLVI.

Zone of Amaltheus oxynotus.

Fig. 1. AMALTHEUS LYMENSIS, *Wright.* Side view, natural size. My collection.
2. — — — Front view of the same fossil.
3. — — — Lobe-line with lobes and saddles enlarged, from a tracing of the fossil.
4. — OXYNOTUS, *Quenstedt.* Side view, natural size. My collection.
5. — — — Front view, natural size, same shell.
6. — — — Lobe-line with lobes and saddles enlarged, from a tracing of the fossil.



A.Gawan del et lith

Hanhart imp

PLATE XLVII.

Zone of Amaltheus oxynotus.

Fig. 1. AMALTHEUS LYMENSIS, *Wright.* Side view, natural size, of a fine specimen with the shell.

2. — — — Front view of do. do.

3. — — — Lobe-line complete, highly magnified.

4. — SIMPSONI, *Bean.* Side view, natural size. Woodwardian Museum, Cambridge.

5. — — — Lobe-line of do. do.

6. — — Side view of smaller specimen, natural size.

7. — — — Front view of do. do.

Fig 4

PLATE XLVIII.

Zone of Amaltheus oxynotus.

Fig. 1. AMALTHEUS LYMENSIS, *Wright.* Side view, natural size; a highly ribbed variety.

2. — — — Front view of do. do. My collection.

3. — WILTSHIREI, *Wright*, nov. sp. A side view, natural size. My collection.

4. AEGOCERAS PORTLOCKII, *Wright*, nov. sp. Siphonal area, natural size. Museum of Irish Survey, Dublin.

5. — — — Side view, natural size do. do.

Fig 1

Fig 2

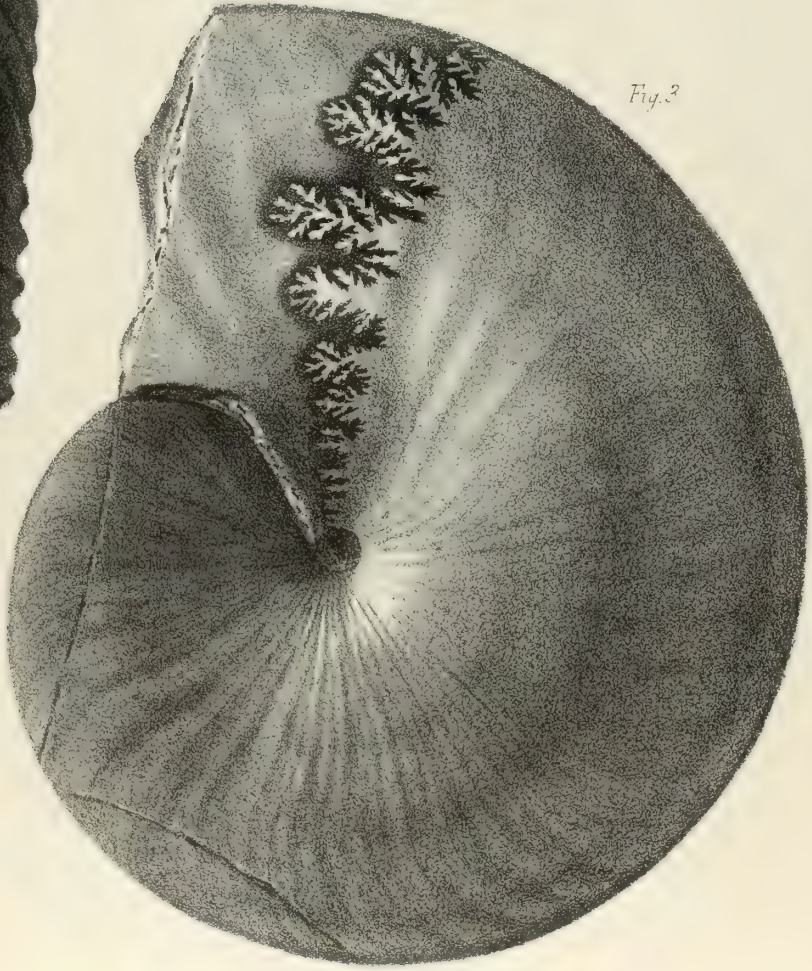


Fig 3

Fig 4

Fig 5

A.Gawan del.et lith

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A MONOGRAPH

OF

THE FOSSIL REPTILIA

OF THE

LIASSIC FORMATIONS.

BY

PROFESSOR OWEN, C.B., F.R.S.,
FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,
ETC. ETC.

PART THIRD.

ICHTHYOPTERYGIA.

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„ pages 41—81, Plates XVII—XX, January, 1870,	„	„	1869.
„ pages 83—134, Plates XXI—XXXIII, May, 1881,	„	„	1881.

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MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

LIASSIC FORMATIONS.

Class—*REPTILIA*, Cuv.[1]

Order—Ichthyopterygia, *Owen*.[2]

Genus—Ichthyosaurus, *König*.[3]

A. Introduction.

Remains of the extinct marine Reptiles, now known as *Ichthyosaurs*, have attracted the attention of collectors and describers of organic fossils for nearly two centuries past.

In Scheuchzer's 'Querelæ Piscium,' 1708, tab. iii contains figures of the biconcave vertebræ of an *Ichthyosaur* from the Lias of Altdorf, supposed to be a fish. Knorr, also, in his 'Naturgeschichte der Versteinerungen,' vol. ii, represents, in figs. 5—7 of tab. i, vertebræ of the same Reptile, as "*Ichthyospondylen*."

So, likewise, when the attention of more modern palæontologists was awakened to remains of the remarkable subjects of the present Monograph, as in the paper by Sir Everard Home, Bart., F.R.S. ('Philos. Trans.,' 1814), we find such described as "Fossil Remains of an animal more nearly allied to Fishes than any of the other classes of animals."

In this paper, however, as in succeeding ones by the same author, which appeared in the 'Philosophical Transactions' for the years 1816, 1818, 1819, and 1820, the accurate and beautiful engravings of the drawings of the several subjects by

[1] Reptiles, *Cuv.*, 'Tableau Elémentaire de l'Histoire Naturelle des Animaux,' 8vo, An. vi (1797), p. 281.

[2] "On the Orders of Fossil and Recent Reptilia," 'Report of the British Association for the Advancement of Science,' 1859, 8vo, pp. 155, 159.

[3] 'Icones Fossilium Sectiles,' fol., pl. xix, fig. 250.

William Clift, F.R.S., enabled contemporary investigators, more capable than Home in determining the true nature and affinities of the fossils, to contribute a durable and rich accession to their science.

In this work the names of Conybeare and De la Beche[1] stand pre-eminent, and with them must be associated that of Charles König, whose appreciation of the affinities of the animal, the fossil remains of which he figured in the work above cited, is exemplified by the generic name which the extinct Reptile has subsequently borne.[2]

Baron Cuvier amply confirmed the conclusions to which the above-cited authors, and, subsequently, Conybeare[3] arrived, and introduced copies of figures illustrative of their papers in the concluding volume of his great work on 'Fossil Remains.'[4]

In the same year Prof. George Fred. Jaeger recognised fossils as Ichthyosaurian in the Lias of Boll, to one of the plates in whose Work reference will be subsequently made.[5]

Subsequent additions to the history of the genus *Ichthyosaurus* will be found in my 'Report on British Fossil Reptiles,' in the volume of the British Association for the year 1839, 8vo., p. 86.

Before entering upon the details of structure and specific characters I may remark that whenever the antecedent representatives of a class or order may be known, to which an extinct genus is referable, the characters of the genus should be compared with those of its predecessors in such class, rather than with its successors or with existing forms, to gain an insight into its true affinities.[6]

The Labyrinthodont order, prevalent from the Carboniferous to the Triassic formation, manifests the tendency to dermal or peripheral ossifications which was carried out to greater extent in older and lower vertebrate forms. The Ichthyopterygian order, prevalent from the Liassic to the Cretaceous period, continues to show the supplementary 'prosquamosals' (Pls. XXIII and XXIV, fig. 1, 27′) and 'postorbitals' (ib. ib., 12); and the vertebral centrums retain the biconcave character (Pl. XXII, fig. 6). The 'foramen parietale' (Pl. XXIII, fig. 1, *f*) is common in Carboniferous,[7] Permian, and Triassic

[1] "Notice of a Discovery of a new Fossil Animal forming a link between the *Ichthyosaurus* and Crocodile; together with general remarks on the Osteology of the Ichthyosaurus," 'Transactions of the Geological Society,' 4to, vol. v, 1821, p. 559, pls. lx, lxi, lxii.

[2] "We have retained in these observations the name Ichthyosaurus, originally applied to this animal by Mr. König, of the British Museum, feeling convinced that on a full and careful review of its whole structure it will not be found to possess analogies sufficiently numerous or strong with the peculiar organisation of Proteus to authorise the change of this appellation into Proteosaurus, as subsequently proposed."—Tom. cit., p. 563, Conybeare and De la Beche.

[3] "Additional Notices on the Fossil Genera Ichthyosaurus and Plesiosaurus," 'Trans. of the Geological Society,' 2nd series, vol. i (1824), p. 103.

[4] 'Recherches sur les Ossemens Fossiles,' 4to, tome 5ème, 2de partie, 1824, p. 447, pl. ii.

[5] 'De Ichthyosauri sive Proteosauri fossilibus speciminibus in Agro Bollensi repertis,' 4to, 1824.

[6] Owen, 'Palæontology,' 8vo, 1860, p. 206.

[7] "Ueber *Archegosaurus Dechenii*, Goldf.," von Dr. G. Jäger, 4to, 'München Abhandl.,' Bd. v, 1847, p. 415, tab. xxvi, fig. 1.

Reptiles; and, in some, is larger than in *Ichthyosaurus*,[1] whence it has been continued on to modern *Lacertilia*, but has become obliterated in the Crocodilian order. Both diapophyses and parapophyses[2] appear in Reptilian vertebræ at the same geological period, and are carried on in the Crocodilian modification of the class, but are lost in existing *Lacertilia*. They are conspicuous Ichthyopterygian characters, and are associated, as far along the spine as they are distinctly developed, with the double-jointed ribs, showing 'capitulum' and 'tuberculum' (Pl. XXI, fig. 2, *a*, *b*). The prezygapophyses of the atlas converge, descend, and aid in forming the anterior cup, which receives a corresponding convex joint-surface of the occipital vertebra; the change from the double condyle of the oldest air-breathing Vertebrates to the single condyle in Triassic Reptilia is retained in the *Ichthyopterygia*. The teeth in this order show a trace of the older Labyrinthodont character in the converging folds of cement penetrating their base,[3] but the alveolar partitions of their native groove are not complete in any part of the tooth-bearing tract. Anchylosis of the tooth-root to the jaw, seen in Mosasauroids and modern Lizards, is not effected in any Ichthyosaur. The teeth retain this freedom, as in Crocodiles, with a similar repeated succession and shedding; as in Crocodiles, also, they are confined to the maxillary, premaxillary, and premandibular ("dentary") bones, but with the ordinal character of much greater length of the premaxillaries than of the maxillaries. The orbits, in *Ichthyopterygia*, are conspicuous for their size; the circle of sclerotic plates usually found fossilised in them exemplifies a primitive vertebral character under a modification continued on in *Chelonia*, *Lacertilia*, and *Aves*. The nostrils are distinct, and antorbital in position. The limbs are natatory, with many-jointed digits, and these exceed, in some Ichthyosaurian species (Pl. XXX, fig. 3), five in number. The scapular arch (Pl. XXVIII, fig. 4, *Ich. latimanus*, *Ich. communis*, e. g.), includes an episternum (46) and clavicles (58), with a well-developed coracoid (52) and scapula (51), the latter near to, but detached from, the occiput. The hinder part of the vertebral column is as free for natatory work as in Whales; there is no sacrum, but a pair of pelvic fins is constant, and these, usually smaller than the pectoral ones, are supported by iliac, ischial, and pubic bones. The terminal caudals are modified for the support of a tegumentary fin, but are compressed, not depressed, the fin being vertical, not horizontal.

The adaptive modifications of the Ichthyopterygian skeleton, like those of the Cetacean, relate to their medium of existence; they are superinduced, in the one

[1] 'Descriptive and Illustrated Catalogue of the Fossil Reptilia of South Africa in the British Museum,' 4to, 1876; *Galesaurus*, pl. xviii, fig. 8, 7; *Petrophryne*, pl. xx, fig. 18, 7; *Gorgonops*, pl, xxi, fig. 3, 7; *Dicynodon*, *Ptychognathus*, *Oudenodon*, *Kisticephalus*, pls. lxiv, lxv; *Procolophon*, pl. xxii, figs. 4, 8.

[2] Op. cit., *Pareiasaurus*, pl. x, figs. 1, 3, *d*, *p*; *Dicynodon*, pl. lii, fig. 1; pl. liii, fig. 3, *d*.

[3] A transverse section of the base of the tooth of an Ichthyosaur gave the first clue to the structure of that of the *Labyrinthodon*. 'Odontography,' 1840, p. 201, pl. lxiv B, fig. 3.

case upon a Reptilian, in the other upon a Mammalian type, and both show analogies to the Vertebrates which the "waters first brought forth." But that the Ichthyopterygians did not breathe by means of gills is shown by the absence of the branchial framework, and by the presence, position, and structure of passages leading from the nostrils to the palate for the course of currents of air on their way to lungs, which were protected and worked by movable thoracic-abdominal costal girdles. Herein these old Sea-reptiles rise higher in structure than some modern cold-blooded air-breathers such, *e.g.* as Batrachians and Chelonians.

An Ichthyosaur by the shortness, one may say absence, of neck, and equality of width of the back of the head with the front of the chest, shares with the Whale a resemblance to Fishes, but pushes the likeness closer in the greater number and less length of the vertebræ, and in the indication of the main joints of the backbone being elastic bags filled with fluid, occupying the intervertebral spaces of the biconcave centrums, as in Fishes, Labyrinthodonts, and modern perennibranchiate Batrachians.

Being cold-blooded, and with a small brain needing a much less supply of oxygen for its work, the Ichthyopterygians, like Fishes, had this advantage over Whales, that their stern-propeller could have the form best adapted for a swift straightforward course through the water.[1] The horizontality of the tail-fin of the Whale tribe relates to their need, as large-brained, warm-blooded air-breathers, to have easy and speedy access to atmospheric air. Without the means of displacing a mass of water in the vertical direction by such broad tail-fin the head of the Whale could not be brought with the needed rapidity to the surface for the purpose of breathing. Nevertheless the Cetaceans are restricted to their element as closely as Fishes, and perish almost, if not quite, as soon when cast ashore, whilst the Ichthyosaurs were less limited in regard to medium, and had a power upon dry land which neither of the other aquatic vertebrates enjoy.

That our Sea-lizards occasionally sought the shore is to be inferred from the strong inverted osseous arch supporting their fore fins, spanning across the chest from one shoulder-joint to the other. In structure this arch closely resembles that in a group of aquatic Mammals (*Ornithorhynchus*), which similarly surpass *Cetacea* in having a command of both land and water, although, by their low position in the mammalian class, they have closer alliance to the *Reptilia*.

There is reason to infer, from examples of diminutive Ichthyosaurs fossilized within the abdominal cage of larger ones, and with the snout directed toward, or partly protruding from, the pelvic outlet, that they were ovo-viviparous and, as a rule, uniparous, reptiles.[2] Others may have sought the shore for sleep or copulation, and have been enabled, by reaction

[1] "Note on the Dislocation of the Tail at a certain point observable in the Skeleton of many Ichthyosauri," 'Trans. of the Geological Society,' 2nd series, vol. v, 1838, p. 511, pl. xlii.

[2] As first shown in the specimen of Ichthyosauri from the Lias of Boll, described and figured by George Friedrich Jäger, op. cit., tab. i, fig. 4; subsequently noted by Quenstedt in specimens in the Tübingen Museum; also by Channing Pearce ('Report of the British Association,' 1874).

of their large and strong fore paddles against the scapular arch, to have crawled or dragged themselves along with the belly resting on the ground.

In outward form an Ichthyosaur (Pl. XXVIII, fig. 1) resembled a huge predatory abdominal fish, with a longer tail and smaller or shallower tail-fin; scaleless, moreover, being clothed by a smooth, probably finely wrinkled, skin,[1] something like that of the whale-tribe.

The mouth was wide and the jaws long, armed, as a rule, with numerous pointed and, in some species, trenchant teeth. Masses of comminuted bones and detached ganoid scales of coeval fishes have been found within the costal cage of the fossil specimens in the situation where the stomach may be judged to have have been. Small, hard, and undigested bodies, containing fish bones and scales, and bearing impressions of the folded surface of the intestinal membrane, have received the name of "coprolites."[2]

Such were the air-breathers which governed the seas of our planet from the Liassic to the Cretaceous period inclusive. At the later epoch the Ichthyopterygians became extinct, and appear to have been superseded by the Mosasaurians. In these the vertebræ have become procœlian; their modified dentition both as to position and attachment is continued on in existing Lizards, but the limbs were fins. The transition, if there was such, is, however, abrupt, and the links are, as yet, unknown which connected the Tertiary cetaceous Zeuglodonts with antecedent whale-like reptiles.

The Cretaceous *Ichthyosaurus campylodon*[3] retains the characters of its order as definitely as they are shown in the species of the Muschelkalk or Lias; and the commencement of this type of Reptile seems to be as abrupt as its close. Much remains to be, and may be, discovered indicating the antecedent forms which linked on more closely the *Ichthyopterygia* with earlier air-breathing vertebrates. But with later ones there is no evidence of transitional alliance; they seem to have passed away under the type of structure which I next proceed to explain as far as study of the fossil remains has made it known to me.

B. Osteology.

a. Bones of the Trunk.—In the vertebræ (Pls. XXI and XXII), according to the regions of the column, are to be noted: the centrum (*c*) neurapophyses (*n*), neural spine (*ns*), pleurapophyses (*pl*), hæmapophyses (*h*), hæmal spine (*hs*), zygapophyses (*z*, *z'*), diapophyses (*d*), parapophyses (*p*), and hypapophyses (*hy*). Some of these are autogenous, others exogenous parts.

[1] "Description of some of the Soft Parts with the Integument of the Hind Fin of the Ichthyosaurus, &c.," 'Trans. of the Geological Society,' 2nd series, vol. vi, 1840, p. 199, pl. xx.

[2] Buckland (Dr. Wm.), "Discovery of the Fæces of the Ichthyosaurus," 'Trans. of the Geological Society,' 2nd series, vol. iii, 1835.

[3] 'Monograph on the Fossil Reptilia of the Cretaceous Formations' (Palæontographical Society's volume, 4to, 1851).

The centrum is more or less antero-posteriorly compressed (Pl. XXII, figs. 1 to 7, 9, 14), with concave terminal articular surfaces (ib., fig. 6) not intercommunicating; on each side of the shallow myelonal canal (Pl. XXII, figs. 2 and 4, *m*) is the deeper, usually triangular, articular surface (*np*) for the neurapophyses (*n*). These, in each vertebra, converge, and, save in the atlas (Pl. XXI, fig. 1, *n*), coalesce at their summits with each other and with the neural spine (ib. figs. 2, 3, 4, *n*, *ns*). In most Fishes the neural arch coalesces with the centrum, as in Cetaceans; its separate state is a saurian, chiefly crocodilian, modification; it is such in the Ichthyosaurs, and adds to the power of inflecting the spine vertically, as in the specimen (Pl. XXIX, fig. 2).[1]

Most of the neurapophyses interlock by means of coadapted zygapophyses (Pl. XXI, fig. 6, *z*, *z'*). The hæmapophyses are developed beneath the abdominal ribs (ib., fig. 2, *h*, *h'*,) and beneath the bodies of most of the caudal vertebræ (ib., figs. 4, 5, *h*); they are always distinct from their centrum (*c*), and do not coalesce below with each other, or with a hæmal spine. The hypapophyses remain detached in the first two or three vertebræ (ib. fig. 1, *hy*), and have advanced to the interspace between their own and the antecedent centrum. That of the atlas (Pl. XXIII, fig. 5, *hya*) is wedged between it and the basioccipital (*o*); that of the axis (ib., *hyx*) between it and the atlas, and so on (ib., *hy*, 3). Conybeare, who first noticed this structure, describes it as follows:—"We have only seen the inferior piece or body (if it can be so called) of the atlas; and the odontoid process (which in all reptiles forms a distinct piece) of the axis; they very nearly resemble those of the turtle."[2]

In the trunk the centrum of the atlas (Pl. XXIII, figs. 2—5, *c a*) is the most modified of that series of vertebral elements. Its fore surface (ib., fig. 2) presents at its upper two thirds a concavity (*c a*), occupying the medial two fourths of its transverse extent, the cavity gradually changing to convexity (*b*) in the lateral fourth. Beneath this smooth concavo-convex articular surface is a rough, flat, triangular surface (*t*), inclining from its upper base backward. The upper joint-surface (*c a*), is for the basioccipital (Pl. XXIII, figs. 1, 2, fig. 5, *o*, in dotted outline), the lower one (*t*), is for the hypapophysis (Fig. 5, *hya*). The hind surface of the atlantal centrum (Pl. XXIII, fig. 4) is flat, and with

[1] More extreme and abrupt vertical flexures, shown in two specimens in the British Museum, may be posthumous, due to disturbance of the decomposing carcase prior to final burial in the Liassic mud, in and with which the skeleton subsequently became petrified.

[2] 'Trans. Geol. Soc.,' vol. v, 1821, p. 574. The homology of the "odontoid process" as the "centrum of the atlas," and that of the anthropotomical "body of the atlas" with the hypapophysial part of that vertebra, is shown in my "Description of the Atlas, Axis, and Subvertebral Wedge-bones in the Plesiosaurus," 'Annals and Magazine of Natural History,' vol. xx, 1847, p. 217, figs. 1—6.

In 1835 Sir P. de M. Grey Egerton communicated to the Geological Society his discovery of not only Conybeare's "inferior piece of the atlas," but the homotypal parts of the two succeeding vertebræ ('Proceedings of the Society,' vol. ii, No. 41, p. 192), and subsequently gave a detailed description, with figures, of these parts under the name of "subvertebral wedge-bones;" 'Trans. Geol. Soc.,' 2nd series, vol. v, 1836, p. 187, pl. xiv.

a few feeble ridges at its peripheral and commonly lower third part. It is rare to find this element unanchylosed with the succeeding centrum (ib., fig. 5, *c x*). The neural surface of the atlantal centrum (ib., fig. 3) is divided equally between the medial quadrate tract (*m*) for the myelon,[1] and the lateral subtriangular depressions (*n p*) for the neurapophyses. The length or fore-and-aft diameter of the atlantal centrum is usually relatively less than in the trunk- or tail-vertebræ of the same individual. The neurapophysial surface bends down upon the side of the centrum, forming a prominence (fig. 5, *d*) on its upper part, representing the diapophysis ; beneath this, with a non-articular interval, projects a low obtuse parapophysis (ib., *p*).

The neurapophyses of the atlas (fig. 6, *n*), as far as I have been able to infer from this commonly mutilated or much disturbed part of the fossil skeletons, were not united together atop, or there developed into an exogenous spine, but retained their distinctness, like their antecedent homotypes the exoccipitals (Pl. XXVI, fig. 1, 2). In the best preserved specimen each atlantal neurapophysis is bent back at the middle of its length, the upper compressed portion overlapping the fore part of the base of the neural spine of the axis, as shown in Pl. XXIII, fig. 6.

Of the existence of the atlantal pleurapophysis (Pl. XXIII, fig. 5, *pl, a*), each being joined by a bifurcate proximal end to the di- and par-apophyses of the centrum, there is better evidence. Such rib was short, directed outward and backward ; and is unconnected, distally, with any hæmapophysis (Pl. XXI, fig. 1, *pl*).

The hypapophysis of the atlas (Pl. XXIII, fig. 5, *hy, a*, and Pl. XXVII, fig. 2) is an irregular triangular robust ossicle, smooth and convex on its inferior and free surface, with the opposite articular surface divided into three facets. The anterior of these (ib., fig. 2, *a*) is smooth and concave, completing, with the concave part of the atlantal centrum, the cup for the basioccipital ball ; an almost flat rough tract (ib., *b*) next below articulates synchondrosaly with the corresponding rough surface of its centrum. Beneath this is a smaller flat roughish surface (ib., *c*), sloping backward from the one above, for articulation with the succeeding hypapophysis. Such are the complex characters of the first trunk-vertebra of *Ichthyosaurus*.

The centrum of the second vertebra (Pl. XXIII, fig. 5, *cx*, and Pl. XXVII, figs. 3, 4, 5), has a flattened, roughish, anterior surface (fig. 4), like the posterior one of the first vertebra, with which it sooner or later coalesces. The hind surface of the axis-centrum (fig. 5) is more deeply and entirely concave, with a sharpish circumferential margin. On the upper surface of the centrum (fig. 3) the myelonal surface (*m*) is similar in size and shape to that of the atlas, but is shallower. The neurapophysial surfaces (*n, n*) are less excavated, and the diapophysial productions (fig. 4, *d, d*) upon the sides of the centrum are more prominent, better defined as processes. The same may be said of the parapophyses (ib., *p, p*), which project close to the fore border of the side surface and show a more distinct facet for the head of the axial rib than do those of the atlas. The

[1] ' Spinal marrow,' ' spinal cord,' of ' Anthropotomy.'

length of this rib is a little more than the vertical diameter of the centrum. The lateral surfaces of the centrum of the axis-vertebra are antero-posteriorly concave, of greater extent behind the rib-processes; vertically they describe a convex curve converging from each side to an inferior medial ridge. This ridge is interrupted, anteriorly, as if that end had been obliquely cut off, forming a roughish subconcave facet for the hind half of the base of the second or axial hypapophysis (Pl. XXIII, fig. 5, *hy, x.*) This element is barely half the size of the one in front, is conical, the apex downward; the base is divided into the surfaces respectively joined to the contiguous hypapophysial facets of the atlas and axis. The neurapophyses converge as they rise and coalesce to form the base of a neural spine (Pl. XXIII, fig. 6, *n s*), the antero-posterior extent of which equals the height—a proportion which distinguishes that part of the second vertebra. Postzygapophyses (ib., *z*) are developed from the base of the spine which overlap and articulate with the prezygapophyses (*z*) of the third cervical vertebra.

Thus, at the fore part of the vertebral column, the neural arch presents the three following modifications:—In the atlas the neurapophyses remain distinct and develop neither post-zygapophyses nor neural spine; in the axis they coalesce, develop the post-zygapophyses and a lofty spine, broader than those in the succeeding vertebræ; the neural arch of the third cervical develops both pre- and post-zygapophyses (Pl. XXIII, fig. 6, *z, z*) and a neural spine (*ns*), subcompressed like that of the axis, but narrower antero-posteriorly: in both vertebræ the neural spine inclines rather backward.

The above descriptions and figures are from an immature specimen of *Ichthyosaurus longifrons.*

In the vertebræ along about a third or more of the trunk, the neurapophysial surface is continued on to the diapophysial process (Pl. XXII, figs. 1—3, *np, d*). This process next becomes distinct (ib., fig. 4, *d*); and, as the parapophysis continues to be developed, the presence of the pair of tubercles, *d, p*, near the fore margin of the side of the centrum characterises that part as far as the fortieth or forty-fifth vertebra in *Ichthyosaurus communis.* In this course both processes gradually descend (ib., figs. 5, 7, *d, p.*), but the diapophysis more rapidly, until it coalesces with the parapophysis, forming therewith an oblique ridge or rising. In the caudal vertebræ the ridge gradually contracts to a rounded tubercle (ib., figs. 9, 11, *d, p.*), and finally disappears at about the eightieth vertebra (ib., fig. 14). At this part of the column, in *Ich. communis,* the abrupt bend or dislocation of the caudal series commonly occurs; and here three or four of the centrums become more compressed than either those that precede or those that follow them, and their lateral margins are raised, as if by forcible compression.

The neurapophysial facets become detached from the diapophyses (*d*) by contracting in breadth, and take the form of narrow longitudinal grooves (Pl. XXII, fig. 4, *p*), bounding laterally the myelonal surface (*m*). This surface sinks a little deeper into the centrum as the vertebræ recede in position, and in the caudal region it contracts both vertically and laterally, until it loses definition in the extreme vertebræ.

The articular bases of the neurapophyses undergo corresponding modifications; the joint-surface is subtriangular, somewhat protuberant in the anterior vertebræ; but, after the diapophysis or rib-surface gets independent, that for the neurapophysis becomes longitudinal, narrow, and grooved. The neurapophysis rises, with a slight receding from the vertical position, for a height usually equalling its fore-and-aft breadth; it develops a short prezygapophysis and inclines backward, with a postzygapophysial surface at its under and hinder part. The pair of neurapophyses having then coalesced send upward and slightly backward a subquadrate compressed neural spine, usually twice the height of the the subzygapophysial part or pedicle (ib., fig. 6, *n*) of the neurapophysis, and with gradually augmenting height and antero-posterior breadth as far as the midpart of the trunk. Towards the hind part the spines begin to lose height, but not breadth, until they enter the caudal region, when they gradually decrease in all dimensions, and disappear at or near the bend of the tail. Feeble emarginations at the fore and hind part of the pedicle form or bound the nerve-outlets.

The contour of the centrum (Pl. XXII) varies with the number and position of its lateral processes. At the fore part of the column it is more or less shield-shaped (fig. 3), with the angles of the upper border rounded off; at the hind part, where the rib-processes have descended (fig. 8) or have coalesced (fig. 11, *dp*), the base is below and the apex truncate for the neural arch; further on, where those processes have disappeared, the contour becomes ellipsoid or elliptic, with the long axis vertical.

The centrum is always short in proportion to its breadth and depth, but this varies in different species; beyond the atlas and axis it is always biconcave (ib., fig. 6), but the contour of the concavity varies specifically. In some the sinking begins at the periphery; in others in a feebler degree there; in others a slight and narrow marginal convexity (fig. 3) precedes or leads to the central concavity; in others, again (fig. 8), a peripheral portion of the joint-surface is flat before it sinks into the central hollow; in exceptional instances, the fore and hind concavities blend at a small central perforation, as they do in the Triassic 'Tretospondilia' of the Cape.[1]

The pleurapophyses (dorsal ribs, Pl. XXI, fig. 2, *pl*) are developed, as free movable elements, over a larger proportion of the vertebral column than in most other four-limbed *Reptilia*, extinct or existing (Pl. XXVIII, fig. 1). They commence at the foremost segment as shown in the description of the 'atlas' (Pl. XXIII, fig. 5, *pl*), gain slightly in length on the axis, in a greater degree on the third vertebra, and acquire their extreme length between the tenth and thirtieth (Pl. XXI, fig. 2, *pl*, and Pl. XXVIII, fig. 1); beyond this they shorten, but continue as free elements, though short and straight (Pl. XXI, fig. 4), along a great part of the caudal region; their existence, as such, being attested in detached centrums by the single sessile process (Pl. XXII, figs. 9—11, *dp*) on each side: with the disappearance of the di-parapophysis the ribs cease. All the ribs

[1] 'Quarterly Journal of the Geological Society,' vol. xxxii, p. 43 (1875).

are comparatively slender, commonly subcylindrical; the longer ones, or those of the trunk, are longitudinally grooved on their outer surface (Pl. XXI, fig. 7), as if each rib consisted of two confluent more slender ones.[1] This structure is not common to all the species. A transverse section which I made exposed a small central cavity.

The hæmal or costal arch is complete along the major part of the trunk. Here the hæmapophyses are each in two partially overlapping pieces (ib., fig. 2, *h*, *h'*); they are more slender than the pleurapophyses.[2] The median piece (hæmal spine, *hs*) is transversely extended, symmetrical, slightly produced at its thickest midpart, forward and backward, but more extended laterally, there becoming slender and diminishing to a point. A similar slender piece, pointed at both ends (*h'*), is spliced as it were, to the fore part of each lateral production of the medial piece. A second styliform hæmapophysis (*h*) is similarly adapted to the fore part of the foregoing style; but as it approaches its pleurapophysis it is slightly thickened, and is joined by a truncate end to that of the pleurapophysis (*pl*). Of the five bones which thus constitute the hæmapophysial part of the thoracic-abdominal hæmal arch, the two on each side I regard as a divided hæmapophysis, and the transversely extended medial piece as the hæmal spine, or abdominal "sterneber." A small but strong triradiate hæmal spine ("episternum") closes the dislocated occipital hæmal arch formed by the modified pleurapophyses ("scapulæ") and hæmapophyses ("clavicles").

In the caudal region the centrum, save at the terminal pinnigerous part, shows a small tubercle at or near each of the four angles of the quadrilateral space (Pl. XXII, figs. 9, 12), forming the lower surface, the anterior tubercles (*hy*, *hy*) being the largest. Each has an articular surface, and the contiguous ones of coadapted centrums give attachment to the base of a short and slightly bent hæmapophysis. These elements, of the same pair, converge as they descend, but do not coalesce to form a "chevron-bone," nor is a hæmal spine developed. These inferior or hæmal arches cease on the terminal twenty or more vertebræ; in most of these the centrum is subcompressed, especially where the seeming fracture or abrupt bend (Pl. XXVI, fig. 8) takes place.

b. Bones of the Head.—The results of my studies in the craniology of the species of *Ichthyosaurus*, subsequent to the 'Report on British Fossil Reptiles' of 1839, were given in the 'Hunterian Lectures,' at the Royal College of Surgeons, London, 1855; and in those delivered at the Museum of Practical Geology, Jermyn Street, in 1858.[3] I have found but little to add or alter in the course of subsequent researches in the preparation of the present Monograph.

[1] Clift, 'Phil. Trans.,' mdcccxiv, pl. xix (1814, *Ichthyosaurus platyodon*).

[2] Ib., 'Phil. Trans.,' mdcccxix, pl. xiv (1819, *Ichthyosaurus communis*).

[3] Notes of these Lectures were published in the 'Annals and Magazine of Natural History,' 3rd series, vol. i, 1858, p. 388 *et seq.*

The general form of the skull of the typical species, *Ichthyosaurus communis* (Pl. XXVIII, fig. 1), as in *Ich. breviceps*, *Ich. intermedius*, *Ich. lonchiodon*, and *Ich. platyodon*,[1] resembles that of the Cetaceous Dolphins (*Delphinus tursio* and *Delphinus delphis*). In *Ich. acutirostris* (ib., fig. 2) the beak is produced to the shape of that of a gigantic stork, while *Ichthyosaurus tenuirostris* and *Ich. longirostris* (ib., fig. 3) rival or surpass the *Delphinus* (*Inia*) *gangeticus* in the length and slenderness of the jaws.

The main difference in the Sea-reptiles lies in the restricted capacity of the brain-case, the seeming expanse of the cranium being due to the great depth and breadth of the post-orbital part of the zygomatic arches or outer walls of the temporal fossæ. A more essential departure from the warm-blooded Vertebrates is the persistent individuality of those cranial elements which, though primitively distinct, become blended into single bones in the higher and later developed forms. The Ichthyosaurs further differ from the marine mammals in the great extent of the premaxillary and the small size of the maxillary bones, in the great capacity of the orbits and the circle of sclerotic plates lodged therein, and, finally, in the antorbital vacuities serving as external bony nostrils.

The occipital region of the skull (Pl. XXVI, fig. 1) is of great breadth and of moderate height. In its formation there enter not only the basi-, ex-, super-, and par-occipitals, but also part of the parietals, mastoids, tympanics, zygomatics, prosquamosals, and pterygoids.

The chief feature is the large proportional size of the basi-occipital (ib., 1), the outer surface of which is divided into an articular (Pl. XXV, fig. 1, 1′) and non-articular part (ib., 1). The articular portion is in the form of a hemispheric, convex condyle, in some species showing a subcentral depression, but deriving no contribution from the exoccipitals, and divided from the 'foramen magnum' by a narrow, upper non-articular tract; the lateral tract gains breadth as it descends along the sides of the condyle, below which it shows an extent of two thirds the diameter of the condyle; but this part of the basioccipital, in extending forward, deviates little from the perpendicular, and belongs rather to the hinder than the under surface of the cranium. The upper non-articular part of the basi-occipital, dividing, in the specimen under description, the condyle from the foramen magnum, is one eighth the diameter of the condyle; then come the depressions for the sutural joints with the exoccipitals, a mere crest dividing them. The exoccipitals (Pl. XXVI, fig. 1, 2, 2) are small and reniform; their bases almost meet above the basi-occipital; their obtuse summits are divided by the base of the super-occipital (3), which contributes about a fourth part of the circumference of the foramen magnum (*f*).

The fore part of the basioccipital presents, in some species, a slight notch or groove, as if for the outlet of an Eustachian canal. This canal, in Crocodiles, traverses the basi-sphenoid, close to its suture with the basioccipital.

The basioccipital articulates, below or in front, with the basisphenoid (Pl. XXV, fig. 1, 5)

[1] See CLIFT'S excellent figure in 'Philos. Trans.,' MDCCCXIV, pl. xvii.

laterally with the paroccipitals (Pl. XXVI, fig. 1, 4); but between these and the basisphenoid it joins the mesially inclined hinder end of the pterygoids (ib., 24). The apex of the superoccipital (3) is wedged into the interspace of the hinder bifurcation of the parietal bones (7′), which it underlaps and partly supports; its base forms the upper border of the foramen magnum. The paroccipitals (ib., 4, 4), broadest where they join the basioccipital, contract as they extend outward into a strong triedral bar, which abuts against the tympanic (28), at the interval between the mastoid (8) and pterygoid (24).

The centrum (1), neurapophyses (2), neural spine (3), and parapophyses (4) of the hindmost cranial vertebra are instructively demonstrated by the Ichthyosaurian condition of the 'occipital bone' of Anthropotomy.

The basisphenoid (Pl. XXV, fig. 1, 5) presents, on its under and outer surface, the form of an irregular, subquadrate plate, narrowest behind, where it joins the basioccipital, expanding as it advances, the anterior border presenting a rough, sutural, notched surface, at its middle third, for the presphenoid (9), and a smooth emargination on each side forming the hind border of the sphenopterygoid or 'interpterygoid' vacuities (*s*, *s*).[1] The hinder half of the under surface of the basisphenoid presents shallow rough depressions and feeble risings for muscular attachments, and, like the basioccipital, it is imperforate. Of the alisphenoids I have been unable to determine more than their presence and their small size. The side walls of the brain-case proper seem to have been mainly cartilaginous.

The parietals (7) in most Ichthyosaurian skulls retain their median (sagittal) suture (Pl. XXIII, fig. 1, 7), which usually opens out anteriorly to form the hind end of the 'foramen parietale' or fronto-parietal fontanelle[2] (*f*), the chief part, or whole, of which is bounded by the frontals (11).

The upper surface of the parietals seems, by reason of the aspect of the occipital portion, to be divided by a ridge (*r*) extending from the mastoids (8′), and continued upon the parietals to their mid-suture, into an anterior (7) and posterior (7′) surface. This masto-parietal ridge (8″ *r*) properly bounds, above, the occipital surface, to which the parietals thus contribute about a fifth part of their length above the superoccipital bone (Pl. XXVI, fig. 1, 7′). Anterior to this ridge each parietal slopes to the temporal fossa (Pl. XXIII, fig. 1, T), the parietal surface being divided by a low longitudinal rising continued forward from a posterior convexity into two facets, both of which are concave across. The dividing ridge is overlapped by a postero-mesial angle of the postfrontal (12), between which and the frontal a narrow forward continuation (7″) of the parietal is exposed, which overlaps the

[1] 'Anatomy of Vertebrates,' vol. i, p. 157, fig. 98, *D*, *s*.

[2] "This foramen, or 'fontanelle,' is common in the Triassic *Reptilia*. It is described and figured in *Galesaurus*, *Petrophryne*, *Dicynodon*, *Ptychognathus*, *Oudenodon*, *Kisticephalus*, and *Procolophon*; in the latter it is large. It is wholly 'parietal' in *Kisticephalus* and *Ptychognathus*, in which it is placed far back."—'Descriptive and Illustrated Catalogue of the Fossil Reptilia of South Africa in the British Museum,' 4to, 1876.

hind part of the frontal. The margins of the sagittal suture usually rise into a low ridge, which is continued upon the occipital part (7′) of the parietal. Of this part (Pl. XXVI, fig. 1, 7′) the surface on each side of the mesial ridge is feebly concave, almost flat, laterally overlapped by the mastoids (8″); it seems to rest upon, without sutural junction with, the superoccipital (3). The postero-lateral extension of the parietal (Pl. XXVI, fig. 1, 7 *x*) curves down beneath the mastoid (8) to within a third part of the lower end of that bone, contributing therewith to the upper and lateral parts of the broad occipital surface.

The mastoid (8, 8′, 8″) is a large and strong triradiate bone, the rays inclining forward from the outwardly obtuse centre or body forming the prominence at each postero-lateral angle of the skull. The upper and inner ray or branch (Pl. XXIII, fig. 1, 8″) is three-sided, one facet looking upward, a second backward, the third forward and outward, contributing, with the parietal, to the outer and hinder wall of the temporal fossa (t). The angle at which the anterior joins the superior facet is continued forward upon the ridge (8″*r*), dividing the hinder and upper facets of the parietal bone. The lower mastoid branch (Pl. XXVI, fig. 1, 8) is a broader plate, smooth, and almost flat externally, forming the upper sides of the occipital region, articulating outwardly with the prosquamosal (27′) and tympanic (28), and below with the pointed process of the pterygoid (24), wedged between the mastoid and tympanic, and here overlapped by the paroccipital (4) in its way to abut against the tympanic. The outer branch of the mastoid, smooth and subconvex outwardly (Pl. XXIV, fig. 1, 8′), extends forward to form the hinder half of the upper zygoma, overlapped by the post-frontal (Pls. XXIII, XXIV, figs. 1, 12), and articulated along its lower border with the broad sclerodermal plate ('prosquamosal,' 27′)[1] occupying the interval between the upper and lower zygomata.

The tympanic is abruptly divided into an upper auditory or proper tympanic portion (Pl. XXVI, fig. 1, 28) and a lower articular portion (ib., 28′). The former is a narrow, subcompressed, outwardly subconvex, bony piece, and is wedged between the mastoid (8) and prosquamosal (27′); its hind or mesial border extends from the mastoid junction to articulate with the pterygoid (24); the outer or lateral border is smoothly rounded and concave, forming more than the hinder half of the auditory meatus (*m*). The suddenly expanded, thick, articular portion (28′) joins the pterygoid (24) mesially and the zygomatic (27) laterally, then descends obliquely backward, for an extent equal to the auditory portion, to thicken and terminate in the surface for the articular element of the mandible. This surface is obliquely suboval, convex from before backward, slightly concave transversely at its fore part.

The hyoid, or hæmal arch of the second cranial segment, is represented by a basihyal and by a pair of rib-like bones (Pl. XXV, fig. 3, 38), homologous with the thyrohyals

[1] This osseous plate is described in my "Report on British Fossil Reptiles," 'Reports of British Association,' 1839, 8vo, p. 9, as the "squamous element of the temporal bone;" it is analogous therewith but not "homologous."

in the Crocodiles, which elements they resemble in their small relative size, but are of more simple structure. Each is feebly and regularly bent, the convexity (in the petrified skull) turned towards each other, converging forward to their junction with the small flattened basihyal, which junction seems to have been by much ligamentous tissue. I noted in a fossil cranium of a full-sized *Ichthyosaurus communis* that the hind ends were $4\frac{3}{4}$ inches apart while the fore ends were but $1\frac{1}{2}$ inch apart. The total length of the bone was 4 inches 2 lines; the breadth of the hind end was $\frac{1}{2}$ an inch, that of the mid-part 5 lines. In the *Ich. lonchiodon* (Pl. XXXI, fig. 5) each thyrohyal is a fifth part the length of the mandible. The stylohyals appear to have retained their fibro-cartilaginous or cartilaginous tissue, and have consequently disappeared.

The presphenoid (Pl. XXV, fig. 1, 9) is a long, slender, trihedral bone, broadest where it joins, and commonly coalesces with, the basisphenoid (5) and, along the narrower part, with the two lower sides, converging to a median obtuse angle. It divides the long and narrow, pear-shaped interpterygoid vacuities (*s*, *s*).

Of the orbitosphenoids I have no exact knowledge; they may not have been ossified, there is no trace or sign of the lacertian columellar bone near that part of the cranium.

The frontals, or midfrontals (Pls. XXVII, fig. 1, 11), are small, transversely convex in greater or less degree according to the species, curving in toward the mid-suture in most, and bending outward and downward to the obtuse angle intervening between the nasal (15) and the postfrontals (12). At the hind end of the frontal suture each border curves outwardly to contribute their large share to the 'foramen parietale,' then converging and, in some species (*Ich. latifrons*, Pl. XXVII), wholly encompassing it; here, also, as in some other species, the midfrontals distinctly join the postfrontals. In all the species the hind border joins the parietal (7), the fore border the nasal (15). The midfrontals are widely separated from the orbits by the postfrontals and nasals. I have not had clear evidence of their touching the prefrontals, or of the presence of distinct superorbitals. In *Ichthyosaurus latifrons* (Pl. XXVII, fig. 1) the frontal suture becomes obliterated, and the bone (11) is convex lengthwise as well as across.

The postfrontals (ib., and Pl. XXIII, fig. 1, 12) exceed the midfrontals in size. Each extends from a mesial angle outwards, expanding horizontally, and inclining to form its share of the superorbital border; thence the postfrontal is continued backward, bending down to join the postorbital (12′) and prosquamosal (27′), and contracting to a notched and pointed end, which receives and overlaps the fore end of the zygomatic ray of the mastoid (8). The similarity of character in the postfrontal (12) and mastoid (8) is worthy of note in regard to their general homology as cranial diapophyses.

The hæmal or pleurapophysial arch of the third or frontal segment of the cranium is modified to constitute the lower jaw.

In the mandible of *Ichthyosaurus* the articular element (Pl. XXVI, fig. 2, 29)[1] is

[1] Cuvier, 'Oss. Foss.,' v, pt. ii, p. 272, pl. xvi, figs. 4 and 5 (*Varanus*), *d* ('articulaire').

scantly visible in an outside view, being covered by the largely developed and backwardly extended surangular[1] (ib. 30). With this the angular coextends or slightly surpasses behind (ib., 31).[2]

Of both elements the outwardly exposed surfaces (Pl. XXIV, fig. 2), as they advance, gradually diminish to a point; the surangular (30), in *Ichthyosaurus communis*, disappearing between the dentary (33)[3] and splenial (32),[4] in advance of the hinder half of the ramus, the angular (31) terminates between the surangular (30) and splenial (32), as far behind the fore half of the ramus. The hind part of the outer surface of the surangular shows a triangular, almost flat, but feebly concave surface, finely sculptured with linear impressions, converging forwards to the apex of the triangle, and indicative of a muscular insertion. In advance of this part the surface is smooth and feebly convex, gaining in depth by the convex curve of the lower border, and a similar one at the upper border, which feebly simulates a coronoid process. Opposite, or beneath the slender lower boundary of the orbit, the surangular is overlapped by the hinder-jointed end of the dentary (33). An oblique canal opens forward below the coronoid rising, beneath the hind border of the orbit, whence extends forward a channel, becoming shallow and ending beneath the overlapping point of the dentary. The angular (31) gradually diminishes in breadth or depth as it extends forward.

From such views as I have been able to obtain of the inner surface of the mandibular ramus, the articular element (Pl. XXVI, fig. 2, 29), after developing the concavo-convex broad surface for the tympanic, seems to be continued forward as a thinner, deeper plate, corresponding to the 'complementaire' of Cuvier.[5] It, however, develops no coronoid process in Ichthyopterygians, but in some specimens seems to be a detached scale (Pl. XXVI, figs. 2 and 3, 30′), simply applied to the inner surface of the ramus over the line of junction of the surangular and angular elements touching or joining anteriorly the hind end of the splenial.

This element (Pl. XXIV, fig. 2, 32; Pl. XXVI, figs. 3—6, 32) begins behind by a point between the surangular and angular, gains breadth as it advances to become applied to the inner side of the dentary, which it also underlaps and strengthens usually to within the anterior fourth part of the length of that element. The splenial in *Ich. communis* contributes a small part of the outer side of the jaw beneath the anterior pointed end of the surangular.

There is no other indication of lack of outer surface of the ramus than the neurovascular foramen and groove of the surangular and smaller irregular foramina in the dentary.

[1] Cuvier, 'Oss. Foss., v, pt. ii, p. 272, pl. xvi, figs. 4 and 5 'surangulaire,' *f*.

[2] Ib., ib., 'angulaire,' *e*.

[3] Ib., ib., (*Varanus*), 'os dentaire,' *a*.

[4] Ib., ib., 'operculaire,' *b*.

[5] Loc. cit., p. 272, *c*.

This important element (Pl. XXIV, fig. 2, 33 ; Pl. XXVI, figs. 4—7, 33) is the longest, if not largest, constituent of the composite mandibular ramus ; it seems not to have carried in any species its symphysial articulation with its fellow to actual confluence. It affords for the lodgment of the mandibular teeth at the hinder half or more of that series only the outer wall and more or less of the floor of a broad and shallow alveolar channel, the inner wall being here supplied by the splenial element (Pl. XXVI, figs. 4 and 5, 32). As the dentary advances it supplants the splenial by developing an inner wall, which finally rises so as to exceed in height the outer one (ib., figs. 6 and 7, 33). The inner surface of the outer wall of the dentigerous groove shows feeble vertical ridges, indicative of alveolar compartments, like those seen along the hinder terminal part of the same channel in *Crocodilia*.[1]

On the outer surface of the dentary, a little below the alveolar border, a series of vascular foramina and grooves leading thence forward is seen in most species of Ichthyosaurs ; in a few species the same surface is indented by a narrow longitudinal furrow. The longitudinal central vacuity of the mandible or interspace between its several constituents is considerable, as is shown in Clift's figure of a transverse section of a ramus.[2]

After comparison of the foregoing structure with the homologous bone in *Reptilia*, I may remark that the mandible of *Ichthyosaurus* differs from that in *Lacertilia* in the minor relative size and backward extension of the 'articular' (29) ;[3] it resembles more the *Crocodilia* in the major relative size of the angular (31), but exceeds in its proportion and position as forming the angle of the jaw, though it is less produced backwards. It differs from both the Crocodilian and Lacertian jaws in the larger relative size of the surangular, which extends backwards so as almost to conceal the articular from outward view. It resembles the *Crocodilia* in the absence of any coronoid process from a complementary element ; also in the larger relative size and length of the 'splenial ;' in this character the Monitors depart less than do the Iguanas from the Ichthyosaurs. In the dentary element *Ichthyosaurus* shows the important affinity to *Lacertilia* in the dental groove, devoid of alveolar partitions ; but in the rudimentary indication of these there is a resemblance, as before remarked, to the short non-alveolar tract at the back of the dental series in some *Crocodilia*. The mandible of *Ichthyosaurus* notably differs from that of Crocodiles, and resembles that of Lizards, in the absence of the vacuity between the angular, surangular, and coronal elements, and in the presence of the longitudinal series of neurovascular foramina or outlets along the outer side of the dentary element.

In the greater extent of the mandibular symphysis *Ichthyosaurus* differs from both

[1] 'Descriptive Catalogue of the Osteological Series contained in the Museum of the Royal College of Surgeons of England,' 4to, 1853, vol. i, p. 167, Specimen No. 765.

[2] 'Philos. Trans,' 1820, pl. xvi. See also Pl. XXVI, figs. 4 and 5, of the present Monograph.

[3] Cuvier, tom. cit., pl. xvi, figs. 4, 8, 13, *d*.

Crocodiles and Lizards; in these, it is limited to a small part of the dentary element, but in *Ichthyosaurus* it includes both dentaries and splenials, and the 'symphysis dentarii' (Pl. XXV, fig. 2, 33) is to be noted together with the 'symphysis splenii' (ib. ib., 32') in the discrimination of species. Thus, the latter is longer than the dentary symphysis in *Ich. intermedius*, but is shorter in *Ich. communis*, and, relatively, much shorter in *Ich. tenuirostris* (Pl. XXV, fig. 3), *Ich. longirostris* (ib., fig. 2), and other long and slender-jawed kinds.

The vomerine bones are narrow, longitudinal, vertically disposed plates, with their lower margins rarely visible at the interspace of the palatines and pterygoids.

The prefrontal (Pl. XXIV, fig. 1, 14) I, as yet, know only by its external or facial part. This is a narrow, moderately long, bony tract, extending from the postfrontal to near the nostril (*n*), there receiving the upper angle of the lacrymal (73) in a notch, the upper branch of which notch is wedged between the lacrymal and nasal, (15); the lower boundary is bent inwards to form part of that of the orbit. The extensive upper and inner border of the prefrontal articulates with the nasal, the short hinder border with the postfrontal.

The position and relations of the prefrontal in *Ichthyosaurus*, as in some Fishes, instructively illustrate its general homology as an element of a cranial segment distinct from that to which the frontal belongs, of which bone it has been regarded as a mere dismemberment. As the neurapophyses of the nasal segment they lend, in *Ichthyosaurus*, a large share of their longitudinal extent to the support of their neural spine, the nasal bone. The large size of both pre- and postfrontals relates to that of the eye and of the cavity destined to contain it in the *Ichthyosaurus*.

The nasals (Pls. XXIII, XXVII, figs. 1, 15) are the longest and largest bones of the cranium proper, but contribute only a small part to the side face; each sends a pointed process backward into a corresponding notch of the frontal which it partially overlaps. The apex of the process is in contiguity with the parietal; a notch on each side the base of the process receives the anterior part of the frontal; the angle of the outer notch touches the postfrontal. By its outer border the nasal unites with prefrontal, lacrymal, and premaxillary (22). The latter overlaps and conceals the naso-maxillary suture in the species in which such may be traced. The upper horizontal parts of the nasals gradually diminish to a point between the nasal portions of the premaxillaries. The exposed extension of the nasals terminates, in *Ich. tenuirostris*, about as far in advance of the nostrils as the fore-boundary of these is in advance of the orbits.

The palatines (Pl. XXV, fig. 1, 20) are long, slender bones, commencing behind at the anterior notch between the pterygoid (24) and ectopterygoid (25), forming, as each advances, the mesial boundary of the small palato-naris (*p n*). The palatine then extends forward, joining mesially the pterygoid, until this diminishes to a point, when the palatines come into contact or near contact with each other at the midline of the palate. Externally the palatine unites with the maxillary (21), but the suture is hidden by the

underlapping extension of the palatal process of the premaxillary (22), which reaches to the palato-naris.

The maxillary (Pl. XXIV, fig. 1, 21) begins behind, parallel with the anterior third of the orbit, from which it is divided by the slender fore part of the malar (26). As it advances the maxillary expands into a facial, an alveolar, and a palatal plate, articulating mesially with the ectopterygoid (Pl. XXV, fig. 1, 25), and, in advance of the palato-naris, with the premaxillary (22). The palato-alveolar part of the maxillary is divided from the facial part by the outer alveolar wall. The facial part (Pl. XXIV, fig. 1, 21), coming into view beneath the fore part of the malar (26), expands slightly to unite with the lacrymal (13), and, in the species affording the subject of fig. 1, Pl. XXIV, it contributes the middle third of the lower border of the nostril; but, as a rule, it is separated therefrom by the junction of the lacrymal (73) with the premaxillary (22), as in fig. 2. In advance of this the maxillary is overlapped by the premaxillary, which conceals it from view at about the fifteenth tooth, counting forward, in *Ichthyosaurus tenuirostris*. In no species does it support more than about one third of the series of teeth on its own side of the upper jaw.

The premaxillary (Pls. XXIII—XXV, XXIX, figs. 1, 22) is characterised by its great relative length. Its facial part begins behind by an expanded bifurcation bounding anteriorly the nostril; in advance of which the bone gradually expands, overlapping the nasal and maxillary, descending to the alveolar border to form the major part of the upper jaw, and narrowing to the end. The palatal portion (Pl. XXV, fig. 1, 22), long and narrow, is continued backward between the maxillary and palatine to terminate in a point penetrating the palato-naris (*p n*).

The pterygoid (Pls. XXV, XXVI, fig. 1, 24) is also a bone of considerable size, especially length. It begins behind by a triradiate expansion; the outer short subquadrate branch abuts against the tympanic (28); the upper narrower pointed ray is wedged between the paroccipital (4), mastoid (8), and tympanic (28); the inner and longest branch is broad, wedged between the paroccipital and basisphenoid, reaching with its blunt-pointed end the basioccipital. In advance of this triradiate expanse the pterygoid contracts, presenting a concave inner border, articulating with the side of the basisphenoid (5), and a more concave outer border, which forms the inner one of the cavity which was occupied by the gristly petrosal. As it continues to advance, the pterygoid again expands, its outer border forming an angular process, to the fore part of which the ectopterygoid (25) unites; the pterygoid then extends forward and gradually inward (mesiad), decreasing in breadth, and is continued as a long and narrow strip of bone in contiguity with its fellow, bounding anteriorly the long interpterygoid vacuity (*s*), articulating outwardly for one half of its extent with the ectopterygoid, and for the other half with the palatine.

The ectopterygoid (Pl. XXV, fig. 1, 25) is an elongate plate of bone, though less than half the length of the pterygoid; its rounded hind end and much of its mesial margin articulate with the pterygoid, the rest with the palatine, with which it combines

to form the hind boundary of the palato-naris (*p n*). The outer margin contributes to bound the pterygomaxillary vacuity (*y*) posterior to its junction with the maxillary, along which it extends to opposite the fifth upper tooth or thereabouts, counting forwards, and there terminates in a point.

The malar (Pl. XXIV, fig. 1, 26) is a long and slender, moderately bent bar of bone, commencing anteriorly in a point wedged between the lacrymal and maxillary, thence receding to form the lower boundary of the orbit, and expanding to be partially overlapped by the postorbital bone (12′), behind which it terminates as a wedge between that bone and the zygomatic.

This bone (ib., 27) is subquadrate, its vertical equalling its longitudinal extent; the angles are more or less produced. The upper anterior one is wedged between the prosquamosal (27′) and postorbital (12x) bones; the lower anterior one underlaps the end of the malar; the front border articulates with both malar and postorbital, the upper border with the prosquamosal; the hind border is rounded and concave, forming the fore part of the 'meatus auditorius externus' (Pl. XXVI, fig. 1, *m*); the hinder half of the under surface of the zygomatic expands, and is slightly excavated to articulate with the outer and upper part of the expanded articular end of the tympanic (28′).

The lacrymal (Pl. XXIV, fig. 1, 73) forms the lower two thirds of the anterior border of the orbit; it sends off from the middle and inner part of this border a short process protecting the lacrymal orifice. The bone contracts vertically as it approaches the nostril, of which it forms the hind concave border. The upper part of the lacrymal sends a process which fits into a notch of the prefrontal (14), anterior to which it joins both the prefrontal and the nasal. Anteriorly, it unites in some species with the maxillary (ib., fig. 1), in most with both maxillary and premaxillary (ib., fig. 2); its lower and longest margin articulates with the maxillary and malar.

The two supplemental skull-bones in Ichthyosaurs, which have no homologues in Crocodiles, are the postorbital (12 *x*,)[1] and prosquamosal (27′);[2] both are present in Labyrinthodonts. The postorbital is the homologue of the lower division of the postfrontal in those Lacertians (*e. g. Iguana, Tejus, Ophisaurus, Anguis*) in which that bone is said to be divided. The postorbital most resembles a dismemberment of an ascending process of the malar; its lower end overlaps and joins by squamous suture the hind end of the malar; whence it slightly expands, rising to the middle of the back of the orbit, thence, gradually contracting as it curves upward and forward, it articulates with the prosquamosal (27′) and postfrontal (12).

Were the prosquamosal (27′) connate with the zygomatic (27) as in *Chelone*, the

[1] Described as "apparently a distinct and peculiar bone" of the orbit in the 'Report' for 1839.

[2] This is termed "squamosal" in the Lectures above cited (1858), p. 392. The recognised distinctness of this bone in *Ichthyosaurus* inclined me in 1839 to view the zygomatic and squamous parts of the temporal bone of anthropotomy as essentially distinct elements; a view which subsequent extensions of comparison enforced me to abandon.

resemblance to those parts of the Mammalian 'temporal bone' would be close, save that the squamous portion would be removed from the inner to the outer wall of the temporal fossa. The prosquamosal holds the place of the temporal fascia in Mammals, and should be viewed as a sclerodermal ossification closing, in *Ichthyosaurus* as in *Labyrinthodon*, the vacuity between the upper and lower zygomatic arches, such as exists in *Crocodilia*. In *Ichthyosaurus* the prosquamosal (27′) is a broad, thin, flat, irregularly-shaped bony plate, smooth and subconvex outwardly, wedged into an interspace between the postfrontal, postorbital, zygomatic, tympanic, and mastoid bones.

The chief vacuities in the skull are:—In the occipital region (Pl. XXVI, fig. 1), the 'foramen magnum' or neural canal of the occipital vertebra (*n*), the 'occipito-parietal,' (*o p*), and the 'auditory' (*m*); on the upper surface (Pl. XXIII, fig. 1), the 'foramen parietale' (*f*) and the 'temporal fossæ' (T); on the sides (Pl. XXIV), the 'orbits' (*o*) and the 'nostrils' (*n*); on the lower surface (Pl. XXV) the 'palato-nares' (*p n*), the 'interpterygoid' (*s*), and the 'pterygomalar' (*y*)[1] apertures.

The 'foramen magnum' is formed by the basi-, ex-, and super-occipitals, the last having an equal share with the exoccipitals; the basioccipital contributes the least part of any. The occipito-parietal vacuities are larger than in *Crocodilia*, smaller than in *Lacertilia*; they are bounded mesially by the ex- and superoccipitals, laterally by the parietals and mastoids, below by the paroccipitals.

The auditory aperture, or 'meatus' (Pl. XXVI, fig. 1, *m*), is bounded by the tympanic and zygomatic. The tympanic takes a greater share in the formation of the 'meatus auditorius' in many Lizards; in Crocodiles it is restricted to that which it takes in Ichthyosaurs.

The orbit is remarkable for its large relative size and backward position: in the former character the Lizards approach the Ichthyosaurs, in the latter the Crocodiles. The cavity is formed by the pre- and postfrontals above, by the lacrymal in front, by the postorbital behind, and by the long and slender malar below. In Crocodiles, and in most Lizards, the frontal or mid-frontal enters into the formation of the orbit, and in some Lizards (*Stellio*, *Agama*) the maxillary also. In Chameleons, both the frontal and the maxillary are excluded from the orbit.

The external nostrils are not homologous with the single medial one in the Crocodiles, but answer to the parial nostrils in Lizards, and to the supplementary apertures bounded by the nasal, lacrymal, and maxillary bones in the Teleosaurs. In Lizards the lacrymal is usually excluded by the maxillary from the nostril. In *Ichthyosaurus* the nostril (*n*) is a longish triangular aperture, with the narrow curved base behind; it is bounded by the lacrymal, nasal and premaxillary (22), sometimes also by the maxillary bones, and is usually distant from the orbit by less than its own long diameter. Like the orbit, the plane of its outlet is almost vertical.

[1] 'Pterygomaxillary' in Crocodiles and Lizards, 'Anat. of Vertebrates,' vol. i, pp. 156 and 157, fig. 98, *y*.

The interpterygoid vacuity (Pl. XXV, fig. 1, *s*) is a very long and narrow triangular one; its base is behind, and is bounded by the anterior concavities of the basisphenoid. As it advances it is divided for a certain extent by the presphenoidal rostrum; the lateral boundaries are due exclusively to the pterygoids, which, converging, reduce the aperture to a point. In this formation, *Ichthyosaurus* resembles *Iguana*, but in *Varanus* the palatines enter into the formation of the palatal vacuity in question.

The pterygomalar vacuity (Pl. XXV, fig. 1, *y*) may be described as the lower outlet of the temporal fossa; it is bounded laterally by the zygomatic and malar, chiefly the latter bone; posteriorly by the tympanic, anteriorly by the maxillary, mesially by the ectopterygoid and pterygoid; the outer deep emargination of the latter bone relates to the passage of the large temporal muscles for insertion into the mandible. The larger proportion which the maxillary contributes to this vacuity in recent Saurians suggested the term 'pterygo-maxillary,' applied to it in the undercited work.[1]

The palato-nares (ib., *pn*) are relatively smaller than in most Lizards, and are circumscribed by the palatine, ectopterygoid, maxillary, and premaxillary bones. In Lizards the ectopterygoid is excluded from its formation, and the position of the palato-naris is more advanced than in *Ichthyosaurus*. The *Crocodilia* depart widely from the *Ichthyosauri* in their single and backwardly placed palatal nostril.

The 'foramen parietale' (Pl. XXIII, fig. 1, *f*) receives a much smaller proportion, if any, of the parietal bones than of the frontals in its formation (Pl. XXVI, fig. 1).

The upper outlet of the temporal fossa (Pls. XXIII and XXVII, fig. 1, T) is bounded mesially by the parietal, laterally by the mastoid and postfrontal, behind by the mastoid and parietal, in front by the postfrontal; the lateral or outer wall of the fossa is formed by the mastoid, postfrontal, prosquamosal, postorbital, malar, and zygomatic bones.

More or less of the circle of sclerotic plates are commonly preserved in the fossil skulls of *Ichthyosauri*. They are of an irregular, oblong, quadrate form, joined together by squamous or overlapping sutures at their longest sides. The hind part is usually about half the length of the plate, and is very thin, ending in a trenchant border; the front or pupillary corneal border is thicker, shorter, and nearly straight. From this border each plate extends, raylike, outward, for more than half its length, then suddenly bends towards the back of the eyeball, defining and encasing its periphery, and indicating the extreme oblateness of that visual spheroid. In the *Ichthyosaurus communis* I have counted seventeen of these sclerotic plates.

c. Pectoral and Pelvic Arches and Appendages.—The limbs of *Ichthyopterygia*, as the name of the order implies, resemble the fins of Fishes in the number of digital joints or segments, and, in some species, the seeming excess of digits beyond the typical 'five.' With the parial ones of Fishes these Reptilian fins also correspond, the anterior pair with the 'pectorals,' the posterior pair with the 'ventrals.'

[1] 'Anatomy of Vertebrates,' vol. i, p. 156.

The inverted arch[1] supporting the 'pectorals' is detached from the occiput, as in the Plagiostomes; that supporting the 'ventrals' is also detached from the 'sacrum,' but retains the position beneath the vertebræ, which, when coalesced, receive that anthropotomical name. The hinder arch[1] has gained a structure determinative of the homology with the hæmovertebral elements called 'pelvis,' and the limbs so supported are called 'pelvic.'

The pectoral arch (Plate XXVIII, fig. 4) consists of a pair of scapulæ (51), a pair of coracoids (52), a pair of clavicles (58), and an episternum (46). In some specimens there appears a trace of a pair of precoracoids.

The correspondence with the same arch in *Ornithorhynchus* was pointed out and figured by Clift.[2] I have not seen an *Ichthyosaurus* in which the clavicles were confluent mesially as a single bony arch, resembling the Avian 'furculum;' but such confluence does take place in the full-grown or aged Monotremes. No sternebers succeed the episternum in *Ichthyosaurus* as they do in *Ornithorhynchus*.

The episternum is small; each clavicle exceeds the length of the anterior transverse ray; the medial longitudinal ray or stem does not exceed the transverse portion in extent. The clavicles are powerful bones, pointed at each end, overlying the transverse rays of the episternum, and continued along the anterior border of the scapulæ towards or near to the 'base' or free extremity of those bones; the joints are rough or sutural. The scapulæ are oblong, subcompressed, truncate at the free or basal end, thickened and broadened at the opposite or articular end for the two joint-surfaces of the coracoid and humerus (53) respectively.

The two pairs of limbs (ib., fig. 1, *s*, *p*) have been found in every sufficiently preserved skeleton, and where such fins have been lost their supporting arches or some elements thereof have usually indicated their existence. Of these limbs the anterior or pectoral (*s*) surpass in size, but in different degrees according to the species, the posterior or pelvic (*p*) pair. They appear to be most nearly equal in size in the skeleton, in part restored, of the *Ichthyosaurus platyodon* (Pl. XXXI, fig. 1), but confirmatory evidence of the degree of difference is desirable in regard to this species. The pelvic pair is the smallest relatively in *Ichthyosaurus latimanus*, *Ich. communis*, and *Ich. breviceps*, but the inferiority is nearly the same in *Ich. intermedius* (Pl. XXX, fig. 1).

In all the species the digits are supported by flattened, subquadrate, hexangular, pentangular, transversely quadrate, or rounded phalanges, exceeding in number in each digit that known in any other Reptile, and recalling the many-jointed rays of the pectorals and ventrals of Fishes.

The shorter-snouted species have the greater number of digits, with more and smaller phalanges; as the jaws proportionately elongate the number of digits decrease, and their phalanges become relatively larger and fewer.

[1] The definition of 'girdle' in our Dictionaries is inapplicable to these parts of the skeleton.

[2] 'Philos. Trans.,' MDCCCXVIII, p. 32, pl. ii.

In all Ichthyosaurs the pectoral limb includes a humerus (see the typical restoration, Pl. XXXIII, fig. 1, 53), two antibrachials (54, 55), three proximal carpals (56), and four distal ones (56′), from which the more numerous series of ossicles (57) are continued. I shall here limit the description of this part of the skeleton to the modification presented in the *Ichthyosaurus communis* (Pl. XXVIII, fig. 1, *s*).

In this species the length of the humerus is but one fourth more than its breadth, and this is greater at the proximal than the distal end. The joint-surface of the head of the bone is subconvex, produced outwardly or anconally upon a thick deltoid ridge, subsiding half way down the shaft; there the ancono-thenal compression becomes more marked and is continued to the distal end, which is pretty equally divided into two subconcave, almost flattened, surfaces for ligamentous union with the antibrachials.

Assuming the prone position of the fin, which presents to outside view its anconal surface, as in Fishes, the anterior antibrachial represents the radius (54), the posterior one the ulna (55). Both bones are pentagonal by reason of the truncation of their distal approximated angles, which give lodgment to the proximal angle of the middle hexagonal carpal bone; the radial and ulnar carpals are transversely oblong, and the quadrangular shape is but slightly disturbed by the production of their contiguous borders into the intervals between the midcarpal and the two metacarpals, which it partly supports. The radial and ulnar ossicles of this third series from the humerus are extended transversely; the four of the following series articulate each with its corresponding metacarpal.

The series of three bones (Pl. XXXIII, fig. 1, 56) presents the same relation to the antibrachials as does the proximal row of carpals in *Testudo*;[1] and the series of four ossicles which follows might be homologised with the distal series of carpals in the same number in *Testudo*. In this case the next transverse row of four ossicles, the third from the antibrachium, may be regarded as metacarpals (57). According to this view the radial metacarpal (57), not the ulnar one (57′) supports two digits, and the normal digits in *Ichthyosaurus communis* are thus five in number (I, II, III, IV, V). Each consists of a series of flattened, somewhat transversely extended ossicles, of which I have counted thirty and upwards in the two ulnar digits of the present species; they are rather fewer in the two radial and the mid-digits. But, in addition to these multiplied digital joints there are two superadded marginal series of ossicles; that (I′) on the radial border of the fin begins between the second and third joints of the radial digit, and is continued to near its extremity. The series (V′) along the opposite, ulnar, margin, begins at the interval between the ulnar proximal and distal carpals, and is also continued to near the extremity of the fifth normal digit. These supplementary ossicles are more rounded in shape than the normal phalanges, but, like these, progressively decrease in size to the tapering end of the fin. At first view, apart from the preceding homological analysis of the bones of the fore limb of *Ichthyosaurus*, they seem to show that seven digital series are present in that fin of *Ich. communis*.

[1] 'Anat. of Vertebrates,' vol. i, p. 174, fig. 108, *a*, *d*, *c*.

All are enveloped in one sheath of smooth integument, which is continued beyond the framework to an obtusely pointed end, and likewise extends some way beyond the hinder or ulnar border of the bones, where it seems to have been supported by numerous fine cartilaginous rays unless the appearance be interpreted as due to parallel bifurcate wrinkles of the skin (Pl. XXVIII, fig, 5).[1]

The ilium (Pl. XXX, fig. 5, 62) is an oblong, subcompressed bone, slightly enlarging at the acetabular end to form the articular surfaces for pubis, ischium, and femur; sometimes, also, more slightly expanding to the opposite free flattened end. This part, if attached to any of the vertebræ, would be so by ligamentous or soluble tissue. The length of the ilium does not exceed, usually, that of three contiguous centrums.

The ischium (ib. 63), of minor length, is thickened at the acetabular end, which shows facets for the ilium, the pubis, and its share in the shallow styloid cavity for ligamentous attachment of the head of the femur. The body of the ischium expands, more or less in different species, to its free non-articular border, anterior to which it unites synchondrosally with the pubis. This (ib., 64) is usually a somewhat longer bone; it also expands to join the ischium at its lower end; the opposed borders of the two bones are concave, and inclose a long and large 'obturator' vacuity.

Modifications of these pelvic elements are shown in *Ichthyosaurus communis* and *Ich. latifrons*, and will be noticed in some other species.

The femur (Pl. XXXI, fig. 1, 65) resembles the humerus, but is smaller and usually rather less broad. Its distal end supports two cnemial bones, repeating the shape and relative proportions of the antibrachial ones. To these succeed three tarsal ossicles, which support four series of digital ossicles. But in *Ich. communis* the anterior or tibial series soon bifurcates, and supplementary ossicles are applied to those of the fibular or hinder digit. The shape of the ventral or pelvic fin thus supported is similar to, but relatively less broad (in *Ich. communis*) than, the pectoral one.

The rare illustration given in Plate XXVIII, fig. 5, is of a pelvic fin.

d. Osteological Summary.—At the risk of some repetition the following remarks, the result of such comparisons as I have had time or means of extending over the cold-blooded air-breathers, may not be unacceptable. The comparison with existing *Reptilia* is almost restricted to the Lacertian and Crocodilian modifications.

In Crocodiles the exoccipitals leave an intervening tract of the basioccipital, which thus takes its share in support of the 'medulla oblongata'; in Lizards the exoccipitals meet upon the basilar element, as in *Ichthyosaurus*, but the extinct Reptile differs from both in the exclusive formation, by the basioccipital, of the condyle articulating with the atlas. Such joint in Fishes is afforded by the basioccipital only, but the articular surface, as a rule, is concave instead of convex. The superoccipital is excluded from the foramen

[1] 'Transactions of the Geological Society,' 2nd series, vol. vi, p. 199, pl. xx.

magnum in Crocodiles, but contributes, in Lizards, a share thereto, as in *Ichthyosaurus*. The paroccipital is confluent with the exoccipital in both Crocodiles and Lizards, as it is in Plesiosaurs.[1] It remains distinct in Chelonians as in Ichthyosaurs.

The extension of the mastoid upon the occipital region of the skull gives it an aspect of solidity more like that in Crocodiles than in Lizards; but this is an adaptive conformation, and depends on the need of an extent of bony surface for the implantation of the powerful nuchal muscles mainly concerned in wielding a head produced into long and heavy jaws, beset, as a rule, with formidable teeth; it also relates to the stability of the prow of the Fish-lizard in cleaving the watery element. The occipital aspect of the diverging extensions of the parietals, and the presence of the 'fontanelle,' called 'foramen parietale' in Plesiosaurs[2] as well as Ichthyosaurs, are more decisive instances of the closer affinity of Lizards, than of Crocodiles, to the antecedent marine types of *Reptilia*. No part of the parietal extends upon the occiput in Crocodiles, but this is the case in Plesiosaurs as in Ichthyosaurs.

In adaptive relation to the mandible and its armature I regard the relative size and shape of the tympanic, the number of bones amongst which it is wedged, and the double buttresses extended on each side from the facial to the cranial part of the skull. In these characters the Ichthyosaurs resemble the Crocodiles; but the upper or postfronto-mastoid zygoma and the lower malo-zygomatic one are present in some extinct as well as existing Lizards, *e. g. Rhynchosaurus*[3] and the *Rhynchocephalia*.[4]

In the exclusion of the mid-frontal from the orbit *Ichthyosaurus* differs from the Crocodiles and from most Lizards, but it is in the Lacertian order only that exceptions occur of repetitions of this Ichthyosaurian structure.[5] In the position, construction, and parial character of the external nostrils the Lizards repeat the Ichthyosaurian and Plesiosaurian type, from which the Crocodiles have departed, but the lacrymal is excluded from the formation of the nostril in all Lizards. In the small relative size of the maxillaries, especially as compared with the premaxillaries, *Ichthyosaurus* differs from both Plesiosaurs and Crocodiles, and still more from Lizards: here we have in Fishes the nearest resemblance to the subjects of the present Monograph. Nevertheless, as in *Lacertilia*, the anterior boundary of the external nostril is formed by the premaxillary; and, as the marine *Reptilia*, like the marine *Mammalia*, needed to have the nostrils at or near to the upper part of the head, so, agreeably with the Lacertian type, the premaxillaries, however they might be produced forward, retain in *Ichthyosaurus*, as in *Plesiosaurus*, the posterior relations with their antorbital nostrils.

[1] 'Monograph on the *Sauropterygia*,' Palæontographical Vol. for 1863 (1865), p. 8, pl. iii, fig. 1, 2–4.

[2] Ib., pl. xvi, fig. 1, 7.

[3] 'Trans. Cambridge Philos. Society,' vol. vii, 4to (1842), p. 350, pl. v.

[4] 'Catal. of Osteological Series in Mus. Coll. Surgeons,' 4to, 1853, p. 143, No. 663; and GÜNTHER 'Phil. Trans.,' MDCCCLXVII, p. 32.

[5] In *Chameleo parsoni*, *e.g.* CUVIER, 'Oss. Foss.,' v, pt. ii, pl. xv, fig. 80.

Both Lacertians and Crocodilians differ from Ichthyosaurs in the connections of the nasal with the maxillary. The Crocodiles resemble them in the inter-premaxillary suture; its presence is an exception in Lacertians, the Rhynchosaurians and Rhynchocephalians[1] again affording such examples; I have found it obliterated in a *Plesiosaurus dolichodeirus*.[2] In the position and formation of the palatal nostrils the Lacertians agree with, whilst the Crocodiles widely depart from, the Ichthyosaurian type. The apertures are distinct or parial in the Plesiosaurs, but are placed far back.[3]

In the structure of the mandible the dentary resembles that element in Lizards, and differs from that in Crocodiles, in being pierced externally by a longitudinal series of nervovascular foramina; it differs, also, from the dentary in Crocodiles in its posterior termination being above instead of beneath the fore end of the surangular. In the amphicœlian Crocodiles the vacuity between the angular and surangular is much reduced in size; it is still smaller in Rhynchocephalians; it is absent in Ichthyosaurs, as in Plesiosaurs[4] and most Lizards.

In the conformation of the posterior angle and the robustness of the articular extremity of the mandible the jaw of *Ichthyosaurus* more nearly resembles that of the Crocodiles than of the feebler Lizards, but in the mandibular structures indicative of affinity these latter existing Reptiles manifest their closer connection with the *Ichthyosaurus*. This is conspicuously seen in the absence of distinct alveoli and the lodgment of the teeth of both upper and lower jaws in a continuous open channel, the inner wall of which, in the mandible, is in a large proportion contributed by the splenial element. But the cement-clad base or root of the tooth seems not to become anchylosed to the alveolar tract or groove in *Ichthyosaurus*, but to remain free, till shed, as in Crocodiles. Although a portion of the pulp-cavity may persist in the fully developed tooth after the base or root becomes consolidated by a mass of interblended osteodentine and cement, into this mass the crown of the successional tooth presses, and occasions a cavity by absorption.[5] In no case have I found evidence of this successive supply of new teeth in the Triassic or Permian Theriodonts: herein differs their dentition from both Crocodilian, Dinosaurian, Lacertian, and Enaliosaurian *Reptilia*.

In most Lizards the hyoid bones present modifications which relate to the size and uses of the thick, or long, and commonly bifurcate, tongue. In *Ichthyosaurus* the apparatus is reduced to the same number of pieces as in the Crocodile, in which it is less

[1] Monogr. cit., pl. xvi, fig. 1, 22. "On the Affinities of Rhynchosaurus," 'Annals and Mag. of Nat. History,' iv, 1859, p. 237.

[2] Monogr. cit., pl. iii, fig. 1.

[3] Ib., pl. xvi, fig. 2, *r*, *r*.

[4] Monogr. cit., pl. ii.

[5] 'Catalogue of the Fossil Reptilia and Pisces in the Museum of the College of Surgeons,' 4to, 1854, p. 40, Nos. 139, 140. In No. 141 I point out that in some of the teeth "the pulp-cavity has been obliterated in the crown as well as in the base of the tooth." See 'Quarterly Journal of the Geological Society' for May, 1879, pp. 189 and 199.

subservient to the support and movements of the tongue than to the mechanism for defending the larynx and pharynx from the entry of water during the struggles of a submerged prey, when the mouth of the air-breathing destroyer is necessarily exposed to the free ingress of the aquatic medium. The condition of the hyoid apparatus in the *Ichthyosaurus* indicates that its tongue may have been but little better developed than in the Crocodile, and, since the Ichthyosaur obtained its food under the same circumstances which necessitate the hyoid and lingual modifications in the Crocodile, it may be inferred that the hyoid arch was physiologically related to the working of a similar valvular apparatus for defending the orifice of the air-tube from the water admitted into the mouth during the capture of the fishes, the remains of which have been found in the region of the alimentary canal of the great Sea-lizards.

The modifications of cranial structure of the known kinds of *Ichthyosaurus* are chiefly presented by the upper and lower jaws, which become elongated and attenuated in degrees exemplified by the species next to be described. With these modifications are associated increase of number with decrease of size of the teeth, and their total disappearance, finally, as in the Ichthyosauroids of the upper Jurassic beds of Wyoming and some other American localities. For these edentulous Ichthysaurs, their discoverer, Prof. Marsh, has proposed the generic name *Sauranodon*;[1] it is probable that, as in the case of *Cetacea*, showing minor modifications than do the toothed *Ichthyopterygia*, other generic terms for some of these species may be proposed.

C. Species.

a. Ichthyosaurus breviceps, *Ow.*, Plate XXIX.

In the skeleton of this species (Pl. XXIX, fig. 2) the skull is almost equally divided between the antorbital part and that behind; it is about one sixth the length of the entire body, as represented by the vertebral column. This includes, in the specimen figured, 125 vertebræ, of which 46 lie between the skull and pelvis. The neural spines of such trunk-region are lofty, equalling along its major part the vertical diameter of the rest of the vertebræ taken from the base of the spine. The intervals between the spines are very narrow. The centrums are largest at and near the pelvic region. The fore fin has five normal digital series, with smaller supplementary ossicles along both fore and hind borders; it is twice as long and as broad as the hind one.

The specific characters are more fully exemplified in specimens of the skull of larger individuals, which show that the proportions of the rostrum to the rest of the skull in the smaller skeleton may be due to nonage, but the cranial conformation is the same.

[1] 'American Journal of Science,' vol. xvii, p. 85, January, 1879; ib., vol. xix, p. 169, February, 1880.

The skull with the right side shown in profile (Pl. XXIX, fig. 1) was discovered in the thick Liassic Limestone, called "Broad Ledge," at Lyme Regis; and, as usual with such fossils from this locality, is somewhat compressed.

The length of the mandible is 3 feet $7\frac{1}{2}$ inches; that of the upper jaw from the fore part of the orbit is barely 2 feet; and from the fore part of the nostril is 1 foot $4\frac{1}{2}$ inches. These proportions indicate the character of the skull which suggested the specific name.

The species which *Ichthyosaurus breviceps* is thus shown to have approached in size is *Ich. platyodon*, Conybeare; but, like *Ich. trigonodon*, Theod.,[1] it had fewer and proportionately larger teeth.

In the portion of the upper jaw in advance of the nostril of a well-preserved skull of *Ich. platyodon*, the number of teeth is thirty; whilst in *Ich. breviceps* they do not exceed eighteen. In a corresponding extent of the lower jaw of *Ich. platyodon* the number of teeth is thirty-two; in that of *Ich. breviceps* it is twenty-two. The length of the skull from the back of the orbit to the fore end of the upper jaw, in *Ich. breviceps*, is three times and two thirds that of the long diameter of the orbit; in *Ich. platyodon* the length of the skull from the back of the orbit forwards is four times and one third that of the orbit in one specimen, and four times and a half that of the orbit in a larger specimen; the size of the eye and of its bony cavity not augmenting, apparently, *pari passu*, with that of the general bulk of the animal. The sclerotic plates, thirteen in number, have been compressed from within at the side opposite to that exposed, and the parts which were abruptly bent upon the midpart of the eyeball have been pushed into line, and fractured at the bend with the fore parts of these plates.

The mandible shows a specific variety in the proportions of its constituent elements. The angular (Pl. XXIX, fig. 1, 31), which in *Ich. platyodon* has less depth, and in *Ich. communis* much less depth than the surangular, opposite the back part of the orbit, has in *Ich. breviceps* greater depth, and it extends further forwards, viz. within nearly one fourth of the fore end of the ramus, instead of terminating within one third (*Ich. platyodon*), or before it reaches half way to that end (*Ich. communis*).

The maxillary is excluded from the external nostril by the junction of the premaxillary (22) with the lacrymal (73). The malar (26) extends further forward in a slender pointed form, in advance of the orbit, between the lacrymal and maxillary (21). The hinder expanded sutural border of the nasal (15) is sculptured by some strongly marked ridges and grooves.

The swollen base of the tooth is impressed by longitudinal grooves, fewer in the upper (ib., fig. 3) than in the lower ones (fig. 4); the enamelled crown shows finer longitudinal lineations, and the fore border is slightly trenchant. The crown is relatively longer and more slender than in *Ich. trigonodon*, and less compressed than in *Ich. platyodon*. The

[1] And. Wagner, 'Beiträge zur Arten von Ichthyosaurus,' 4to, 1851, p. 34, tab. xvi, figs. 3—6.

teeth come nearer in character to those of *Ich. communis*, but are relatively larger, and fewer in a given extent of the jaws, than in that species.

In all the characters above defined as differentiating the present species from those with which it is compared, and to which it makes the nearest approach in the Ichthyosaurian series, the skull figured as that of *Chiroligostinus* in plate 3 of Hawkins's 'Great Sea Dragons,' fol., 1842, agrees with *Ich. breviceps*, and the name might be adopted were it not applied by that author as a synonym of *Ich. platyodon*. Besides the Dorsetshire locality above named, *Ichthyosaurus breviceps* has been discovered in the Lower Lias in the neighbourhood of Brownish, Glastonbury, Somersetshire, in the Zone of *Arietites Bucklandi*.

b. Ichthyosaurus communis, *Conybeare*. Pl. XXIV, figs. 2, 5, 5′; Pl. XXVIII, fig. 1; Pl. XXX, figs. 3, 4, 5.

The name was suggested by the evidences of this species being the most numerous that, at first, came to hand; but subsequent acquisitions seem to show another species to have a better claim, at least in the locality of the Lias formations in the South-west of England.

In *Ichthyosaurus communis* the length of the skeleton is about five and a half times that of the skull, and the length of the 'snout,' or upper jaw, anterior to the orbit, is three and a quarter times that of the orbit

Of great breadth posteriorly, the skull narrows to the fore part of the orbits, thence the upper jaw contracts rapidly, afterwards gradually, to the anterior almost pointed end. As it advances the upper jaw becomes subcompressed. In profile, after the concavity due to the sinking of the cranium anterior to the orbit, the line goes straight to near the end of the upper jaw, where it rapidly sinks to the alveolar border.

The chief characters of the present species are afforded by the teeth and the pectoral paddles.

The teeth (Pl. XXIV, figs. 5, 5′) are more numerous and smaller than in *Ich. breviceps*, but, in comparison with the majority of the known species, are proportionately large. They have an expanded or ventricose root, contracting to a conical, slightly aduncate crown, with a subcircular transverse section. The apex is subacute, but there is no coronal trenchant margin; the enamel is impressed by fine longitudinal grooves, with intervening ridges. These finer ridges are somewhat abruptly divided from the coarser ones of the root by a smooth tract marking the base of the enamelled crown. Viewed in the series the teeth seem to taper less regularly, often more quickly, to the apex than in other species. The upper jaw bears on each side from forty to fifty teeth, of which sixteen or eighteen may be implanted in the maxillary bone, the rest in the premaxillary. Each ramus of the mandible may support a few teeth more than those opposed to them in the upper jaw.

The midfrontals take the chief share in the formation of the parietal foramen, and are excluded from the upper border of the orbit by the pre- and postfrontals. The sclerotic plates are sixteen or seventeen in number.

The nostril is bounded by a straight line above, contributed by the nasal bone, and by a curved line below, due to the lacrymal and premaxillary. The maxillary is excluded from that opening; it receives the pointed fore end of the malar in a notch; that slender bone forms the whole of the inferior border of the orbit.

In the mandible the surangular extends forward beyond the angular. The dentary elements unite to form the major part of the symphysis, a small hind portion being contributed by the splenials (Pl. XXX, fig. 4, 32′). The symphysis so constituted had, in a lower jaw 2 feet 9 inches in length, an extent of 9 inches.

The vertebræ are shorter, or their centrums have a minor antero-posterior extent in proportion to their breadth, than in some other species (*Ich. intermedius, Ich. latimanus, e.g.*), but are longer than in *Ich. brachyspondylus*. I have counted forty vertebræ between the occiput and the "sacrum," conventionally so calling the centrum nearest the iliac bones. From this to the end of the tail follow, at least, one hundred vertebræ, of which seventy-five no longer support pleurapophyses. The total number of vertebræ in *Ichthyosaurus communis* may be set down at 140.

The episternum shows no marked specific character. The coracoids have the anterior notch deeper than the posterior one (Pl. XXX, fig. 3). The clavicles are long and strong, applied, as usual, to the fore border of the transverse rays of the episternum and to that of the scapulæ.

The bones of both fore and hind paddles have afforded the description given in the preliminary general account of the Ichthyosaurian skeleton (p. 104).

In the specimen (Pl. XXX, fig. 3), in which the pelvic arch and limb are unusually well preserved, the ilium (ib. figs. 5, 62) is sabre-shaped or moderately curved backwards; in length $2\frac{1}{2}$ inches, with a breadth of 5 lines at the middle. The pubis (64) of the same pelvis is 2 inches 9 lines in length, 1 inch in distal breadth; both fore and hind borders are concave. The ischium (63) is nearly of the same length as the pubis, with a distal breadth of 9 lines, and a deeper concavity of the anterior border. The entire vertical extent of the pelvis is 5 inches.

The length of the pelvic paddle in the subject of fig. 1, Pl. XXXIII, is $4\frac{1}{2}$ inches; that of the femur being 1 inch 7 lines. The extreme breadth of the paddle is 1 inch 10 lines. At this part there are five phalanges in transverse line, that number occurring at the fifth bone from the femur. The midtarsal encroaches further between the tibia and fibula than usual.

The *Ichthyosaurus communis* occurs chiefly in the Lias of Lyme Regis and Charmouth, Dorsetshire; in that of Street, Somersetshire, it is rarer than the *Ichthyosaurus intermedius*. Remains of *Ichthyosaurus communis* have been met with in the Lias near Bristol. This species is associated with *Ich. intermedius* and *Ich. tenuirostris* in the Lias

of Barrow-on-Soar; it occurs, likewise, in the same formation at Stratford-on-Avon. In all these localities Ammonites of the species *Arietites Bucklandi* have been associated with the Ichthyosaurian fossils.

c. Ichthyosaurus intermedius, *Cb.* (Plate XXIV, fig. 7, Pl. XXX, figs. 1 and 2).

In this species the orbits are of moderate size,[1] and the facial portion of the skull in advance equals in length about three times the antero-posterior diameter of the orbital outlet. The teeth (Plate XXIV, fig. 7) are relatively smaller and longer than in *Ich. communis* (ib., figs. 5, 5′); the crown has a narrower base, is more acutely conical, with finer longitudinal striæ, and the root has less prominent ridges. The number of teeth is from thirty-five to forty on each side of both upper and lower jaws.

The entire length of the skeleton is from five to five and a half times that of the mandible.

In the best preserved specimens the number of vertebræ ranges between 130 and 140. In the space between the scapula and pelvic arches there are about forty vertebræ, which may be termed 'abdominal.' The neural spines increase in length and fore-and-aft diameter to beyond the middle of this region, and, by reason of their antero-posterior breadth, they are in contact with each other. The fin-bend of the tail occurs at about the seventy-sixth or eightieth vertebra.

The di- and par-apophyses become confluent at or about the forty-sixth vertebra, and such single 'transverse process,' or tubercle, disappears near the tail-bend.

The ribs are slender, and become flattened and longitudinally grooved along their distal halves. After the fortieth pair, or thereabouts, they become straight, short, rounded, without the groove, and resemble mere 'transverse processes.'

Three neural arches in the subject of fig. 1, Pl. XXX, have been dislocated near the bend of the tail. In these, the neurapophyses are short and confluent, with a transversely broad, quadrate neural spine (Cut, fig. 5), the quadrature being due to an abrupt truncation of the spine.

Fig. 5.
Neural arch, front view.
Nat. size.

Fig. 6.
Caudal vertebra, side view.
Nat. size.

[1] Compare with fig. 3, pl. XXVIII, *Ichthyosaurus longirostris*.

In the pinnigerous part of the column the neural arches (Cut, fig. 6) gradually lose breadth, gain length, and still more gradually lose height, the spine always predominating in the fore-and-aft diameter; the summit equals the centrum in that extent, and the neural spines of contiguous vertebræ touch, but do not overlap.

The vertical contour of the midpart of the centrum, above and below a more prominent convex part, is slightly concave. The borders show the moderate convexity or thickening, relating to the compressed characters of the pinnigerous caudals.

The neurapophyses in the basicaudal region seem not to have coalesced above, and the broad, laterally-impressed, and backwardly-produced part, simulates the half of a truncated neural spine. The short, straight, and inferiorly-situated pleurapophyses continue to be developed to near the tail-bend. The shorter hæmapophyses (Cut, fig. 6) are continued from the pinnigerous caudals to within a third part of the pointed tail-bend.

In the skull of *Ichthyosaurus intermedius* the following characters may be noted.

The under surface of the basioccipital is but slightly excavated anterior to the condyle, and the 'foramen parietale' is almost wholly in a raised part of the hind end of the interfrontal suture. The maxillary is separated from the external nostril by the junction of the premaxillary with the lacrymal.

The sclerotic plates are from fifteen to seventeen in number.

The surangular is deeper, and forms a larger proportion of the outer surface of the hind half of the mandibular ramus than the angular. It terminates or disappears at the usual point between the dentary and splenial, in advance of the angular; it develops on its upper border a small but well-marked coronoid angle bounding anteriorly the concavity under the hind part of the orbit. Beneath this angle or process begins the neurovascular groove, which extends, gradually shallowing, a short way forward. The splenial element begins to show at the lower margin of the ramus about the mid-length of the angular; it unites with its fellow to form the hinder two thirds of the symphysis mandibulæ (Pl. XXX, fig. 2, 32′). The articular piece is brought into view by its partial dislocation backward in the right ramus of the subject of fig. 1, Pl. XXX.

The stem of the episternum equals in length one half of the cross-bar; in receding therefrom it slightly expands and becomes flattened. In one young specimen a median cleft extended a short way forward from the end.

The clavicles are distinct, long, and less strong than in *Ich. communis*, feebly bent, with the concavity behind and within, gradually narrowing to each end, and having a sutural surface beneath and behind, some way along each end; the shorter one engrains with the episternal cross-bar, the longer one with the fore part of the scapula. Of this bone the fore border is straight, the hind one concave through the backward production of the humeral joint; near this the outer surface is slightly excavated. In the coracoid the humero-scapular articulation is of less relative extent than in *Ichthyosaurus communis*. The anterior notch is broader, but is as deep as the hinder one; the intervening tract, or neck, is relatively larger than in *Ich platyodon* or *Ich. tenuirostris*.

The present species has afforded the chief ground of the restoration outlined in fig. 1, Pl. XXXIII. The humerus is marked 53; the radius 54; the ulna 55. The fore border of the radius is entire, not notched. The antibrachium supports, as usual, three ossicles (56), followed by four rather smaller (56′). Regarding these as carpals, they support four metacarpal ossicles (57—57′), from which are continued five longitudinal series of progressively diminishing phalanges. The anterior or radial metacarpal (57) supports two digits, of which the radial may be symbolised as I, the next series as digit II. The three other series, III, IV, V, are supported by their respective metacarpals. Each digit consists of numerous phalanges, progressively decreasing to the end. A series of small supplementary ossicles is applied to the radial border of digit I, and to the ulnar border of the digit V, so that seven ossicles may be counted in the same transverse line along the middle third or fourth of the series. The number of phalanges is, however, less than in *Ich. communis*, and the fin is relatively narrower. The characters of the fore paddle above defined are well shown in specimens from the Lias of Lyme Regis and of Street, in the British Museum.

In the pelvic fin the femuris longer in proportion to its breadth, and the distal expansion is relatively greater than in the humerus. The tibial ossicle of the three tarsals has an emarginate tibial border; the corresponding ossicle or phalanx of the second and third series shows the same character.

d. Ichthyosaurus platyodon, *Cb.* Plate XXIV, figs. 4, 4′; Pl. XXXI, figs. 1, 2, 3.

The skull of *Ichthyosaurus platyodon* (Pl. XXXI, fig. 2), is somewhat longer in proportion to the trunk than in *Ich. communis*. Taking as the trunk the extent of the vertebral column to the pelvic arch, such extent includes, in the subject of fig. 1, one length and a half of the skull, while in *Ich. communis* (Pl. XXVIII, fig. 1) it includes rather less than two lengths, and, in *Ich. intermedius* (Pl. XXX, fig. 1) rather more.

The skull of *Ich. platyodon* is longer in proportion to its breadth than in *Ich. intermedius*. The jaws are stronger from the greater relative depth of the mandible and the less gradual attenuation to the rostral extremity. The orbit is of a full elliptic shape, with less approach to the circular, than in *Ich. breviceps* (Pl. XXIX, fig. 1). It is relatively less than in the long- and slender-snouted kinds. The length of the rostrum anterior to the orbit is three and a half times the longitudinal diameter of that cavity.

The osseous circumpupillary ring includes thirteen sclerotic plates in the subject of Pl. XXXI, fig. 2. The surangular (Pl. XXXI, fig. 2, 30) disappears between the dentary (33) and angular (31). This element similarly disappears in a pointed form between the dentary (33) and splenial (32), beyond the midlength of the ramus.

A dental characteristic of the present species is that which suggested to Conybeare the name *platyodon;* the smooth enamelled crown (Pl. XXIV, figs. 4, 4′) being subcompressed, sharp-edged, and pointed; the longitudinal grooves of the tumid cement-clad root are soon lost upon the coronal base. I have counted 45—45 of these teeth in an upper jaw, and 40—40 in a lower jaw, and have noted that the crowns are more often snapped off than in the smaller species, which may be indicative of the greater violence with which they have been used.

From the occiput to the iliac bones there are forty-five vertebræ; thence to near the end of the tail may be counted seventy-five vertebræ; the total number in the skeleton probably somewhat exceeded 120. One of these vertebræ, from the hinder half of the abdomen, is figured (in the inverted position with the neural surface downwards) in Home's Memoir of 1816.[1] The neural spines are thicker, shorter, and more rounded superiorly than in *Ich. intermedius* or *Ich. communis.* The zygapophyses, especially the anterior ones, are well developed, and the vertebræ of the trunk and basal moiety of the tail are strongly interlocked, though admitting some inflection. The ribs increase in length to the twenty-fifth pair; at the thirtieth pair they begin to shorten gradually, and, after the fortieth pair, more suddenly, becoming nearly straight at the forty-fourth pair. Thence they are continued like long transverse processes articulated by a simple head to the single di-parapophysis, as far as the hundredth vertebra.

The scapula (Pl. XXXI, fig. 3, 51) has a relatively broader humeral end than usual. It is preserved with the corresponding clavicle (ib., 58) in a portion of a huge skeleton of the present species in the British Museum.

The coracoid has a relatively larger or longer scapulo-humeral surface than in *Ich. intermedius*, and has a narrower and deeper anterior notch or emargination than in *Ich. communis;* the ento-sternal margin is rather thicker than usual. I have noted a specimen of this bone from Lyme Regis, of which the long diameter was 8 inches 4 lines, the short diameter 6 inches.[2]

The humerus is notable for its breadth, especially distally, compared with its length. The proximal rounded end, or 'head,' is tuberculate at its circumference, indicative of powerful ligamentous attachments to the scapulo-coracoid joint. The fore margin is more concave than usual. This latter character is still more marked in the radius, which, with the ulna, presents the generic shortness and flatness, with a slight excess of breadth, as compared with most other species. The anterior emargination is present also in the radio-carpal bone (Pl. XXXI, fig. 1, 54), and in the corresponding one in the following series. The next ossicle presents the common pentagonal form. Not more than three series of digital bones are preserved in the subject of figure 1, Pl. XXXI. A few supplemental ossicles are preserved at the radial border beyond the middle of the fin-framework. I have not found evidence of a greater number of pectoral digits in any

[1] 'Phil. Trans.,' MDCCCXVI, pl. xiv.

[2] 'Report,' *ut supra*, 1839, p. 114.

remains of the present species. It seems to have been characterised by long and narrow, but powerful fore paddles.

In the pelvic bones the ilium (Pl. XXXI, fig. 1, 62) presents a straight, flattened, slender form. The ischium (ib., 63) is remarkable for its breadth, especially at its medial end. The pubis (ib., 64) is less expanded there; its anterior border is straight.

The femur (ib., 65) is longer in proportion to its breadth than the humerus; its proximal end shows a large depression, probably for the insertion of a stout ligament. The tibia (ib., 66) presents an anterior emargination, as in the radius (54); the same character is repeated in the two succeeding ossicles at the same margin of the fin-framework. Here, also, but three digital series are preserved, with a few small supplemental ossicles along the fibular border of the fin.

The disposition of the distal ossicles in both pairs indicates that the ligamentous or fibro-cartilaginous uniting medium of their framework may have been more abundant than usual, allowing greater flexibility of the terminal part of the long and narrow paddles of *Ichthyosaurus platyodon*. The least incomplete skeleton of this huge species in the British Museum, the subject of Pl. XXXI, fig. 1, is from an individual of about 20 feet in length; but portions of others—the skull, for example, which may be seen at the Geological Society's Rooms at Burlington House—indicate a total length of the individual so represented, of at least 30 feet.

The Lias of the Valley of Lyme Regis is the chief depository of *Ich. platyodon*, but its remains are pretty widely distributed in the same Mesozoic zone. They have been found in the Lias of Glastonbury, of Bristol, of Scarborough, of Whitby, and of Bitton in Gloucestershire. The Ammonites associated with the bones of the subject of Pl. XXXI, fig. 1, are of the species *Arietites semicostatus*, characteristic of the greyish limestone (Lower Lias) of Lyme Regis.

e. Ichthyosaurus lonchiodon,[1] *Ow.* Pl. XXIV, figs. 6, 6′; Pl. XXXI, figs. 4—7.

This species, which appears to have attained a bulk second only to that of the *Ich. platyodon*, differs in the shape and smaller relative size of the teeth (Pl. XXIV, figs. 6, 6′). They are more slender in proportion to their length than in *Ich. communis* (ib., figs. 5, 5′), and are straighter than in *Ich. tenuirostris*. Their base is cylindrical, less ventricose than in *Ich. platyodon* (ib., fig. 4′), and more finely and regularly fluted than in *Ich. communis*. A smooth boundary divides the base from the enamelled crown, and this is traversed by fine longitudinal grooves converging to the apex. The transverse section of its base is nearly circular; it tapers gradually to the apex, which is nearer the posterior line or contour than the axis of the tooth.

The vertebral centrum has a greater proportional fore-and-aft extent than in *Ich.*

[1] 'Report,' *ut supra*, p. 116.

platyodon; the neural arch and spine have a less vertical, in proportion to the fore-and-aft, extent (Pl. XXXI, fig. 6) than in *Ich. communis* or in *Ich. tenuirostris.* Forty-five of these vertebræ may be counted between the occiput and the pelvis; and as many beyond may be made out in the subject of fig. 4, Pl. XXXI, as brings the number up to 120, but the tail is incomplete.

The length of the rostrum anterior to the orbit (Pl. XXXI, fig. 5) includes little more than three longitudinal diameters of that cavity; it is thus relatively shorter than in *Ich. platyodon,* and it is relatively more slender than in *Ich. intermedius.* The mandible, however, does not partake of this proportion, but is nearly as deep and strong, relatively, as in *Ich. platyodon* (ib., fig. 2). The surangular (30) extends farther forward than the angular (31); both disappear in the usual pointed form. The nostril is divided from the maxillary by union of the premaxillary with the lacrymal. The pair of hyoid elements (cerato-hyals) are preserved *in sitû* in the subject of fig. 5; they are cylindrical, almost straight, truncate at each end, which very slightly exceeds in thickness the rest of the bone. Each is about one fifth the length of the mandibular ramus.

The coracoid (Pl. XXXI, fig. 7) shows a deep anterior notch, with only a feeble concave outline at the corresponding part of the hind border of this bone. The clavicle is applied and suturally attached to the lower half of the fore border of the scapula. That border is nearly straight; the hinder one is concave through the backward production of the thickened lower end to contribute to the articular surface for the humerus. The anterior border of the radius and succeeding ossicle is emarginate. The chief phalanges of but three digits are preserved in the subject of Pl. XXXI, fig. 4. The character of the pectoral fin of the present species is probably rightly indicated in the main; and in such essentially tridactyle character *Ichthyosaurus lonchiodon* may agree with *Ich. platyodon.*

The lower or distal ends of ischium and pubis seem to be equally expanded; both bones are broader than the ilium. The ventral fin has been dislocated and bent backward close to the spine. The homotypal ossicles show the same emargination as in the pectoral fin.

This species has hitherto been found only at Lyme Regis; it appears to be a rarer Liassic Ichthyosaur than the three preceding ones. The skeleton above described was discovered by Miss Mary Anning, to whom the discovery and extrication of many rare and interesting fossils of the Lias of this locality are due.

f. Ichthyosaurus longifrons, *Ow.* Pl. XXIII, figs. 1—5; Pl. XXIV, fig. 1; Pl. XXV, fig. 1; Pl. XXVI, fig. 1; Pl. XXVII, figs. 2—5.

The characters of this species are those in which the subjects of the above plates and

of the general description of the cranial organisation of the genus differ in the specific modifications referred to in other sections of the present Monograph.

From the Upper Lias, with remains of *Ammonites bifrons*, of the Cotteswold Hills. The more complete cranial specimen from the same Liassic zone at Curcy, Normandy, has afforded the subjects of the figures in the plates above cited.

g. Ichthyosaurus latifrons, *Kön.* Pl. XXIII, fig. 6; Pl. XXVII, fig. 1.

In the year 1825 Mr. König, Keeper of the Department of Mineralogy, British Museum, published a series of lithographs of fossils, in a folio form, with brief notices of the subjects, reaching to number 100. Beyond this, names alone are given at the foot of each plate, and No. 250 of plate xix bears that of *Ichthyosaurus latifrons*. It is a very reduced view of a mutilated skull and portion of the vertebral column, with some vertebræ outlined of the natural size. The specimen is stated to have been obtained from Lyme Regis.

Of this specimen a view of the upper surface of the skull is here given of the natural size, in Pl. XXVII, fig. 1. The upper apertures of the temporal fossæ (t, t) are nearly equilaterally triangular in form, the base being external and slightly exceeding the sides, which converge to the cranium proper. The sagittal suture (7) persists, but the frontal one is obliterated, and the midfrontals (11) constitute a single symmetrical bone, which is moderately convex both lengthwise and crosswise.

The "foramen parietale," of a full ovate figure, is formed wholly by the frontal, the apex alone forming the beginning of the parietal suture.

The postfrontal (12) extends upon the coronal suture, and overlaps part of both parietal and frontal bones. The nasal (15) overlaps the fore part of the frontal, and divides that bone from the prefrontal (14). The sides of the skull converge rapidly to the beginning of the snout. A breadth of cranium across the temporal apertures of 7 inches is reduced to 2 inches anterior to the nostrils (ib, *n*).

Additional characters of the present species are afforded by a second specimen from Lyme Regis acquired by the British Museum. It is a skeleton, lacking both ends, but including the trunk, with chief part of the skull and basal portion of the tail, the total length being 4 feet 10 inches. From the occipital condyle to the pelvis it measures 2 feet 6 inches; the length of the preserved portion of the skull is 1 foot 4 inches. In this specimen is instructively shown the sudden slope by which the broad cranium descends into the rostrum. The orbit is correspondingly large, its vertical diameter is 5 inches, its antero-posterior one is $4\frac{1}{2}$ inches. The sclerosteal circle is composed of correspondingly large plates, of which seven are preserved.

The vertical diameter of the base of the rostrum, taken across the middle of the nostril, is but 1 inch 3 lines. The premaxillary is impressed by a longitudinal groove, running about three lines above the alveolar border.

The teeth are long, slender, slightly recurved; six or seven may be counted in an extent of two inches of the alveolar groove. The length of the crown of the best preserved is 6 lines, its basal breadth being 1 line.

In the composition of the mandible the angular element is unusually short; it disappears parallel with the hind border of the orbit. On the other hand, the sur-angular is longer than usual, but its chief character is the continuation of the forwardly-directed nervo-vascular foramen, usually present below the hind border of the orbit, into a groove continued forward, towards the lower border of the ramus, and terminating at a vertical line dropped about a nostril's extent in advance of that opening. A second and narrower longitudinal groove extends along the dentary about two lines below the alveolar border.

The length of the jaws cannot be determined in this or in the typical specimen, their fore end being broken off, but sufficient remains to indicate that *Ich. laticeps* belonged to the long and slender-jawed species, with small and slender teeth to match; and associated, as in *Ich. tenuirostris*, with a powerful fore paddle, supported by comparatively few and relatively large phalanges.

The proportion of the longitudinal to the transverse diameter of the vertebral centrums is contrasted with those of the *Ich. brachyspondylus* in Pl. XXXIII, fig. 6. The neural spines of the dorsal vertebræ are relatively short and with distinct intervals. Thirty-eight are preserved between the scapula and ilium.

The scapula is characterised by the greater relative expanse of its articular end in comparison with the breadth of the body, resembling in this respect that of *Ich. platyodon*. The coracoid has a deep anterior emargination, and a shallow posterior one; the antero-posterior breadth of this bone is 4 inches, the transverse extent is 3 inches. The left coracoid, with the corresponding humerus and a few paddle-bones, have been pushed dextrad and appear beneath the right coracoid, from which the corresponding paddle has been removed.

The pelvic bones of the right side are well shown. The ilium, 2 inches 4 lines in length, is directed obliquely backward and downward; its upper end is one inch in breadth. The pubis, 2 inches 3 lines in length, has a distal breadth of 11 lines; its fore border is almost straight. The ischium, 2 inches in length, has a distal breadth of 1 inch 3 lines. The margin towards the pubis is more concave than the opposed one of the latter bone. The hind border of the ischium is moderately concave.

Compared with the same bones in *Ichthyosaurus communis* the pelvic elements are more robust.

Of the structure of the appendage of the pectoral and pelvic arches, or fins, I have not, as yet, obtained satisfactory evidence.

The fossils which have served in the present section of the Monograph have been obtained from the Lias of Lyme Regis and Charmouth.

h. Ichthyosaurus acutirostris,[1] *Ow.* Plate XXVIII, fig. 2.

This species is so named from the slender, sharp-pointed form of the snout, unaccompanied by such proportions of length as characterise the *Ichthyosaurus tenuirostris* and *Ich. longirostris* (ib., fig. 3).

The length or fore-and-aft diameter of the orbit in the subject of the above plate is 6 inches, that of the part of the skull anterior thereto is 18 inches 7 lines. Both upper and lower jaws are impressed by a deep and narrow longitudinal groove near to and parallel with the alveolar border. The osseous sclerotic part of the eyeball occupies about two thirds of the long diameter of the orbit.

The teeth are intermediate in character and in number between those of *Ich. intermedius* and *Ich. tenuirostris*.

The few trunk-ribs preserved in my present subject are slender, rounded, ungrooved, and have a feebly-produced anterior margin along their proximal fourth.

The mesial border of the coracoid is sinuous, the articular surface for the episternum being better defined and more tumid than usual. The surface of the lateral or outer border for articulating with the scapula and humerus is strongly developed. The length of the coracoid in the specimen described is 7 inches, its breadth $7\frac{1}{2}$ inches.

The humerus is 7 inches in length and $5\frac{1}{2}$ inches in breadth at the distal end. Of the fore paddle three digital series and a small portion of a fourth are preserved, but in such juxtaposition as to leave little doubt as to any considerable part of the fin-bones being lost. These, along the fore or radial border, including the radius, radio-carpal, and succeeding ossicle, are emarginate; the rest have that border entire and moderately convex. After the fifth ossicle from the humerus the subquadrate merges into the transversely oval form. From the inclination of the radial digit toward the middle of the fin, a bifurcation is indicated at about the ninth ossicle from the humerus, and an irregular scattered series of small, full-elliptic, and circular bonelets, may be interpreted as an additional digit to the three normal ones, the more direct continuation of digit II now extending down the centre of the bony paddle. An irregular ulnar series like that on the radial side is partially shown. If there should be lack of osseous evidence of the breadth of the fore fin there is less of its length, which seems to have been two thirds that of the skull, and this is due rather to the size than the number of phalanges. The preserved basal portion of the left paddle repeats the character of the

[1] 'Report,' *ut supra*, p. 116.

corresponding part of the right one above described, and so far confirms the inference as to the specific character of the fins associated with the acuminate one of the skull.

The fossils on which the above species of Ichthyosaurs is founded are from the Lias of Whitby, Yorkshire.

i. Ichthyosaurus tenuirostris, *Cb.* Plate XXIV, fig. 8; Plate XXV, fig. 3; Plate XXXII, figs. 1—6.

The characters which, in 1822,[1] strikingly distinguished the present from the then determined species of *Ichthyosaurus,* were the great length and slenderness of the jaw-bones, suggesting the proportions of those of the Crocodilian gharrial; and which, in combination with the large orbits and low broad cranium, gave to the skull a resemblance to that of a gigantic woodcock (*Scolopax*), with a bill armed with teeth.

The length of the snout is chiefly due to the prolongation of the premaxillaries (Pl. XXXII, fig. 2, 22) and dentaries (ib., 33). The length of the skull anterior to the orbit is somewhat less than four times the antero-posterior diameter of that cavity.

The parietals retain their sagittal suture, the fore part of which recedes in a greater proportion than usual to contribute to the foramen parietale. Their posterior bifurcation is applied, in the occipital region, to the super-occipital, which is broad and arched. The outer end of each parietal prong is obliquely truncate for the suture with the mastoid (ib., fig. 2). This, as usual, forms the blunt but prominent supero-lateral angles of the hind part of the cranium. The midfrontals (ib., 11) retain their suture, their lateral border articulates with the prefrontal (14) and the superorbital, or a forward extension of the postfrontal. This element articulates with the lateral border of the parietal and combines with that bone in forming the upper three fourths of the temporal fossa, the lower boundary of that cavity being completed by the mastoid.

The orbit is bounded behind chiefly by the postorbital. The malar is unusually long, extends from the lacrymal (73) to form the rest of the anterior boundary of the orbit; then, continuing to circumscribe it below, the malar curves with a rather abrupt bend upwards to join the postorbital, and by an oblique suture the zygomatic. This bone is continued obliquely backward to contribute to the external meatus auditorius and to articulate with the tympanic.

The sclerotic plates preserved in the orbit of the subject of fig. 2 bend more abruptly than usual towards the back part of the cavity, suggesting a depressed spheroid form of the eyeball.

The nasal (15) presents the usual connections; the margin which it contributes to the upper part of the nostril (*n*) is slightly convex, encroaching on that opening, which

[1] 'Trans. of the Geological Society,' 2nd series, vol. i.

seems to be rather longer, proportionately, than usual: in the subject of fig. 2 it is $2\frac{1}{2}$ inches in length.

In the composition of the lower jaw, I have noted that the angular element extends a short way in advance of the surangular before disappearing externally. The point of the surangular enters a notch in the hind part of the dentary, about half an inch anterior to a line dropped from the fore part of the nostril. The angular disappears, as usual, between the splenial and dentary, not between the splenial and surangular. The splenials contribute a small proportion to the mandibular symphysis (Pl. XXV, fig. 3, 32′).

The teeth (Pl. XXIV, fig. 8) conform in relative size and slenderness of crown with the slenderness of the bones wielding them. Those at the fore half of the jaws incline more backward than usual, and hardly assume a vertical position in the maxillary and post-mandibular regions. I have counted from sixty-five to seventy on each side of the upper jaw, of which twenty-five, or thereabouts, are implanted in the maxillary. In the lower jaw there are about sixty teeth in each dentary (Pl. XXXII, fig. 2, 33). A few detached teeth in a portion of a large *Ich. tenuirostris* from the Lias at Pyx Hill measure, each, 1 inch 4 lines, the enamelled crown being about a third of that length; the cement-clad root is 4 lines in diameter, rather thicker in proportion than in the smaller-sized specimens of the present species.

The vertebral column (Pl. XXXII, fig. 1) agrees in general length with the characteristic shape of the head. In the best preserved specimens it is nearly four times the length of the skull.

I have counted 156 vertebræ in a well-preserved column of the large specimen from Pyx Hill; in this the pinnigerous part of the tail was two feet in length, and had been bent down in the burial and subsequent petrifaction of the Sea-dragon at almost a right angle to the trunk; this deflected part included sixty centrums, which seemed to be relatively somewhat shorter as well as narrower than those of the trunk. At the bent part of the column the margins of the terminal articular facets were slightly deflected, and markedly raised from the level of the sides of the centrum, indicative of the degree and frequency of flexure at this part. The fore-and-aft diameter of a post-abdominal vertebra in an average-sized Tenuirostral is 13 lines, the vertical diameter being 2 inches 6 lines. The terminal articular surfaces of the centrums are more uniformly concave than in the previously described species. I have not found in *Ich. tenuirostris* more than two hypapophyses at the fore part of the column, one wedged between the basioccipital and the atlas, the other between the atlas and axis. This more simple apparatus for fixing the immediate support of the skull suggests an accordance with the lighter and more slender character of that part. The centrums gradually increase in fore-and-aft dimensions to the pelvic region, and do not begin to decrease in size till about ten vertebræ beyond the part forming the base of the long caudal region.

The ribs soon become long and slender as they recede from the head, and increase in length to near the hind end of the abdomen; thence they shorten less gradually than

usual. Forty-five pairs of the long and regularly-curved ribs show the external longitudinal groove.

The parial fins (Pl. XXXII, figs. 4, 6) show a somewhat less disparity in the size of the pectorals and ventrals than obtains in *Ich. communis* and *Ich. intermedius*. Their framework has fewer and larger bones, and the fore paddle impresses one with its massive proportions compared with the vertebræ. The clavicles are relatively more slender than in *Ich. communis*, but of the usual form, diminishing at the two extremities. The scapula is relatively larger than in *Ich. intermedius*, and is thicker and more expanded at the humeral end; its fore border is moderately concave and longer than the hind one. The coracoid (ib., fig. 3, 52) has a broad neck supporting a large and thick scapulo-humeral articulation; it has a deep and narrow anterior notch, and a shallow posterior emargination. In a well-preserved specimen of the present species, in the Philosophical Institution, Birmingham, the length of the coracoid is 4 inches 5 lines, and the breadth 3 inches; the length of the humerus of the same specimen is 3 inches 10 lines, the breadth of its distal end is 3 inches. The transverse diameter of the radius equals the antero-posterior diameter of the centrums of two of the parallel vertebræ; its anterior margin is notched. The ulna has a corresponding size, with a smaller anterior notch circumscribing with an apposed notch in the radius a roundish vacuity. These bones were anchylosed together and to the humerus in the Birmingham specimen. The 'manus' commences by three transversely oval carpals, of which the radial one is notched, as in the radius; but this character is not repeated, as in *Ich. acutirostris* and *Ich. platyodon*, in the next distal bone, nor is the radial digit bifurcate, as in *Ich. communis* and *Ich. intermedius*. There are but three series of digital bones, with a fourth shorter marginal series of smaller ossicles.

In the hind paddle (Pl. XXXII, fig. 6) the femur, like the humerus, has a longer shaft than usual, and not so proportionally broad a distal end. The tibia is notched anteriorly like the radius, but not so deeply; the corresponding tarsal bone is more feebly emarginate. In this fin, also, there are but three series of digital ossicles.

In the Museum of the British Institution there is a skeleton of *Ich. tenuirostris* thirteen feet in length: it is from the Lias of Lyme Regis, Dorsetshire. Evidences of the same species have also been obtained from the Lias of Stratford-on-Avon, of Bristol, of Street, Somersetshire, and at Barrow-on-Soar, Leicestershire.

k. Ichthyosaurus longirostris, *Ow.* Pl. XXV, fig. 2; Pl. XXVIII, fig. 3; Pl. XXXII, figs. 7, 8, 9.

The specimens in the British Museum, from the Lias of Barrow-on-Soar, on which the present species is founded, and the least incomplete of which is the subject of figure

7, Pl. XXXII, have borne the above specific name in the Public Gallery of the Department of Geology for fifteen years. The description was reserved for the present Monograph, and I regret the unavoidable circumstances which have delayed its communication to the Palæontographical Society.

Reckoning the lost terminal caudal vertebræ according to the guiding analogies I estimate the total length of the animal to include four lengths of the skull. Of this part the length of the rostral extension anterior to the orbit is four and a quarter times the antero-posterior diameter of that cavity: and yet the orbit is relatively larger than in *Ichthyosaurus tenuirostris*.

The teeth correspond in size with the slenderness of their supporting jaws; they are of difficult detection; the best preserved show crowns, as in fig. 3, Pl. XXVIII. With sufficient magnifying power traces of longitudinal striæ are discernible on the enamelled crown; the cemented base is as little tumid as in *Ich. tenuirostris*. In the relative minuteness of the teeth of *Ich. longirostris* we may discern the transitional step to the edentulous Ichthyosaurs described by Prof. Marsh.[1]

I conclude that the present, together with other long- and slender-jawed Fish-lizards, may have preyed in a great degree upon the contemporary Cephalopods with internal rudimental shells as well as on Fishes. The eye in *Ich. longirostris* is proportionately large, like the orbit which the sclerotic circle almost occupies, suggestive of the nocturnal habits of the species; the plates seem to have been not fewer than sixteen in number. The present species, like *Ich. tenuirostris*, is characterised by the large size of the pectoral fin, and that of the ossicles representing the carpals and phalanges of its digits. These, however, are limited in number, as in *Ich. tenuirostris;* the three normal digits (II, III, IV) are instructively conserved, though not terminally entire, in fig. 7, Pl. XXXII. The supplementary ossicles here preserved are, situated as in the tenuirostral species, along the ulnar margin, forming a sort of rudiment of the digit (V), which is normally developed in *Ich. communis* and *Ich. intermedius*.

The scapula, clavicle, and coracoid of the same side as the fin are definite, but dislocated. The coracoid repeats the type of that of *Ich. tenuirostris* so far as having the anterior notch the best marked, but the posterior one is more faintly indicated. The anterior notch (Pl. XXXII, fig. 9) is placed further back, and becomes lateral rather than anterior. The articular prominence is also nearer the hind border of the lamelliform bone.

The radius and radio-carpal bone are notched anteriorly, as in *Ich. tenuirostris*.

The pelvic paddle has the same relative size as in that species, and the same tridactyle structure.

I reckon forty-eight vertebræ between the skull and pelvis; fifty-two vertebræ can be made out in the extent of the caudal region preserved; to which may be added about

[1] "A New Order of Extinct Reptiles (SAURANODONTA)," 'Amer. Journ. of Science and Arts,' vol. xvii, Jan., 1879, p. 85.

a score more for the wanting pinnigerous terminal portion of the tail, which probably has been torn off by predatory assailants of the dead reptile.

Besides the Liassic locality of Barrow-on-Soar, specimens and parts of *Ichthyosaurus longirostris* occur in the zone characterised by *Ægoceras angulatum;* also in the zone of *Arietites Bucklandi*.[1]

l. Ichthyosaurus latimanus,[2] *Ow.* Pl. XXXIII, figs. 2, 7.

This species is nearly allied to *Ich. communis* in the size and construction of the pectoral paddle; but the still smaller proportion of the pelvic one suggested the *nomen triviale*, which is vindicated, also, as a sign of specific difference, by the proportionally shorter and thicker jaws and by the modification of the vertebral centrums (Pl. XXXIII, figs. 2 and 7); in this character the present species differs from *Ich. breviceps*.

Ich. latimanus resembles *Ich. communis* in the ventricose, subobtuse character of the teeth, or, at least, some of the more worn ones, of the twenty-nine which may be counted on each side of both jaws. The articular surfaces of the centrum are concave at the middle third, the rest of the surface to the circumference is flat.

In the specimen of *Ich. latimanus*, 6 feet 10 inches in length, and in that of an *Ich. communis*, 5 feet 2 inches in length, the following were the respective dimensions of bones of the scapular arch and its appendage:

	Ich. latimanus.			*Ich. communis.*	
	In.	Lines.		In.	Lines.
Scapula, length of	3	4	...	3	0
Coracoid, antero-posterior diameter .	3	8	...	2	4
Coracoid, transverse diameter . .	3	2	...	2	0
Antibrachials, breadth of . . .	2	5	...	1	7
Length of fore fin, humerus inclusive .	7	6	...	5	0
Breadth of ditto .	3	6	...	2	4

The clavicle is proportionally thicker than in *Ich. communis;* in the skeleton above cited it is 6 inches 8 lines in length.

The head is relatively shorter. In the specimen of which the dimensions are above given the mandible is 1 foot 4 inches in length, while in the *Ichthyosaurus communis* above compared it is 1 foot 5 inches in length.

In a specimen of *Ichthyosaurus latimanus* in the Museum of the Philosophical Institu-

[1] See the classical Monograph, by Dr. Wright, F.R.S., &c., in the volumes of the Palæontographical Society issued in 1878 and 1879.

[2] 'Report,' *ut supra* (1839), p. 123.

tion at Bristol I counted 114 vertebræ; the terminal caudals showed in a greater degree than usual the compressed character indicative of the vertical tegumentary fin.

Parts of the carbonised integument are preserved on the slab of Lias on which lies the above skeleton; faint traces of integument lie above and beneath the deflected caudal vertebræ; a broad patch remains about four inches beyond the last preserved centrum, though not the last of the series. This is the sole direct evidence I have as yet detected of the tegumentary part of the tail-fin. Traces of the abdominal integument appear to be smoother than in the similarly preserved skin figured in Buckland's, 'Bridgewater Treatise.'

If, as has been suggested (p. 86), the pectoral arch and fin relate to occasional reptation on the sea-shore, it may be inferred, from the partial flattening of the articular surfaces of the vertebral centrums, as well as from their proportions, in the present species, characterised as it, also, is by more massive proportions of the pectoral arch and greater relative size and strength of the fore paddles, that it was more littoral in its habits than the majority of these marine Saurians.

Saltford, near Bath, and the Penarth Beds (Rhœtic) of Glamorganshire are among the localities of *Ichthyosaurus latimanus*.

m. Ichthyosaurus brachyspondylus, *Ow*. Pl. XXXIII, figs. 3—6.

This species is founded on vertebral characters, the centrums being shorter in proportion to their height and breadth than in any other that has come under my observation.

In the abdominal centrum, the subject of figures 3—5, Pl. XXXIII, the breadth of the articular terminal surface (ib., fig. 4) is 2 inches 11 lines; the vertical diameter is 3 inches, while the antero-posterior extent does not exceed 11 lines. In a more posterior centrum (ib., fig. 6) in which the diapophysis (*d*) has descended to contact with the parapophysis, the same proportions are preserved with slight diminution of size. In a larger mid-dorsal centrum of this species which I examined in the private collection of Mr. Rose, of Swaffham, the breadth was 3 inches 8 lines, the height 3 inches 9 lines, but the length did not exceed 1 inch 5 lines.

In a collection of fossils from Mid-Jurassic beds in the Province of Moscow, submitted to me by Col. Kiprianoff, in 1853, were centrums showing the same dimensional characters, together with a low medial ridge dividing the under surface, which is, likewise, present in the British specimens. Col. Kiprianoff adopted the name, with my determination, of his Ichthyosaurian specimens, other evidences of which have since been detected and described in a valuable contribution to Russian palæontology by Prof. Trautschold.[1]

[1] Trautschold (Prof. H.), 'Ergänzung zur Fauna des Russischen Jura,' 8vo, 1876, p. 5.

D. Conclusion.

Although a study of the evidences of Ichthyopterygian organisation, of which, and its modifications, as exemplified at the Liassic period, the results are given in the foregoing pages, has left the impression, mainly, of the great additions which wait to reward subsequent cultivators of this field of comparative osteology, I am unwilling to quit it without giving expression to some of the general notions which its cultivation has suggested.

Palæontology has been regarded, if not defined, as including a kind of knowledge of parts, or of structures, in such degree interdependent that, any one being given, others may be deduced as a necessary consequence, such deductions being determinative of the relations of the whole; so far as to give the Knower a power of predicating results, both zoologically, as respects the affinity of the otherwise unknown whole, of which only a part affects the senses, and physiologically, as respects the living powers of the whole and the part such extinct organism played in the sphere of its existence.

This necessary connection and interdependency of the links of structures constitute the essential condition and attractive character of palæontological science. The subject, nevertheless, of the present Monograph, constrains me to submit the question, how far this science of ours has advanced towards sustaining the foregoing definition; in other words, to how much of organic Nature at large, or of particular organisms, it is so applicable.

Let us suppose, for example, that no other part of the petrified frame of an Ichthyosaur had come to our hands than had reached those of Scheuchzer or of Bronn,—a few vertebral centrums, for example, from the hind part of the trunk. Could we have otherwise concluded than they did? Certainly not, had our knowledge of the vertebral structures been restricted to the same parts of the extinct and fossilised animal.

Biconcavity of centrums is a pre-eminently piscine character, but not without exceptions in the class of Fishes, even in that great proportion of the species whose osseous development has advanced to individualised bony segments of the spinal column. Such an exception, *e. g.* we have in the opisthocœlian vertebræ of the Bony Gar (*Lepidosteus*).

But no known kind of Fish possesses vertebral centrums with both upper and lower transverse processes ('diapophyses' and 'parapophyses'). The presence of these in certain of the biconcave vertebræ of *Icthyosaurus*, bespeaks that of ribs having a two-fold articulation with their vertebræ; and such structure of rib implies a body-cage adapted to the movements of expansion and contraction of its cavity, which cavity we infer, therefore, to have contained bags receiving air, and to have had associated movements for the purposes of respiration.

But this function raises the exerciser above the grade of the Fish, and the next ques-

tion of the Palæontologist would be, whether the air-breather was cold-blooded or warm-blooded.

The biconcavity of the vertebræ would sustain the first conclusion, and consequently a reference of the extinct animal, so fragmentarily indicated, to the Reptilian, not the Mammalian class.

But what further insight into the nature of such Reptile could be gained by contemplation of a solitary centrum, or even of a series of vertebræ? With me no further step could be taken toward a sure knowledge of the nature of the cold-blooded air-breather, so partially indicated. A suspicion, at most, of an aquatic medium, and consequently of limb-structures adapted to locomotion therein, might have crossed the mind. But a complete reconstruction of the extinct animal, or certain knowledge of such, could only be the result of acquisition and comparison of the anatomy of the cranium, as well as of the limbs and their sustaining arches; and such has been the knowledge supplied by the subjects of the foregoing pages of the present Monograph.

Here I may remark that instances of ancient extinct forms, manifesting a more generalised type, are more than ever worthy of note in the present phase of biological science; and the *Ichthyopterygia* contribute a welcome addition to this suggestive class of phenomena. In the construction of their chief natatory organ for forward movement may be discerned a combination of mammalian, saurian, and ichthyic conditions. In the great length and gradual diminution of the caudal series of vertebræ may be noted the saurian character; the tegumentary expansion, unsupported by bony rays, recalls the main feature of the cetaceous tail-fin, while its vertical position in the air-breathing Saurian brings it in close parallel relation with the corresponding natatory propeller in the class of Fishes.

Nevertheless, the Ichthyosaur, as an aquatic air-breather, might be supposed to have exchanged, at a loss, the disposition of its terminal fin in comparison with its aquatic warm-blooded, fish-like successors; but the pair of hind pelvic fins, wanting in all Cetaceans, are superadded to the locomotive instruments in the Ichthyosaurs, and were, doubtless, actively applied to bring the nostrils, when needed, within range of the superaqueous atmosphere.

But in almost every extinct natural group of animals peculiar conditions present themselves. In no known cold-blooded Fishes was the visual organ so well, or so conspicuously adapted to the detection of the finny prey as in our present subjects. To unusual size of eyeball, which in Dr. Buckland's experience sometimes reached that of a man's head, was added a circle of concomitantly large bones—the 'sclerotic plates'—of form and structure in harmony with the requirements of the visual outlooks. Was a near object to be detected, the retraction of the bony circle and contraction of its aperture, surrounded by the laterally overlapping plates, would coincide with a concomitant convexity of the cornea pressed upon by the squeezed humours within and with the contraction of the pupil—conditions concurring in the needed microscopic application of the eye.

If the distant expanse of waters was to be scanned, the resumption of the normal position of the sclerotic ring and of the relaxed relations of the overlapping plates would coincide with an expansion of the pupil and flattening of the cornea, whereby the eye would thus acquire a telescopic range. Moreover, the wide transparent corneal aperture of the conspicuously large organ of vision would enable the predatory Saurian to take advatage of the least amount of light penetrating the depths of its marine environment.

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PLATE XXI.

Ichthyosaurus.

Typical vertebræ.

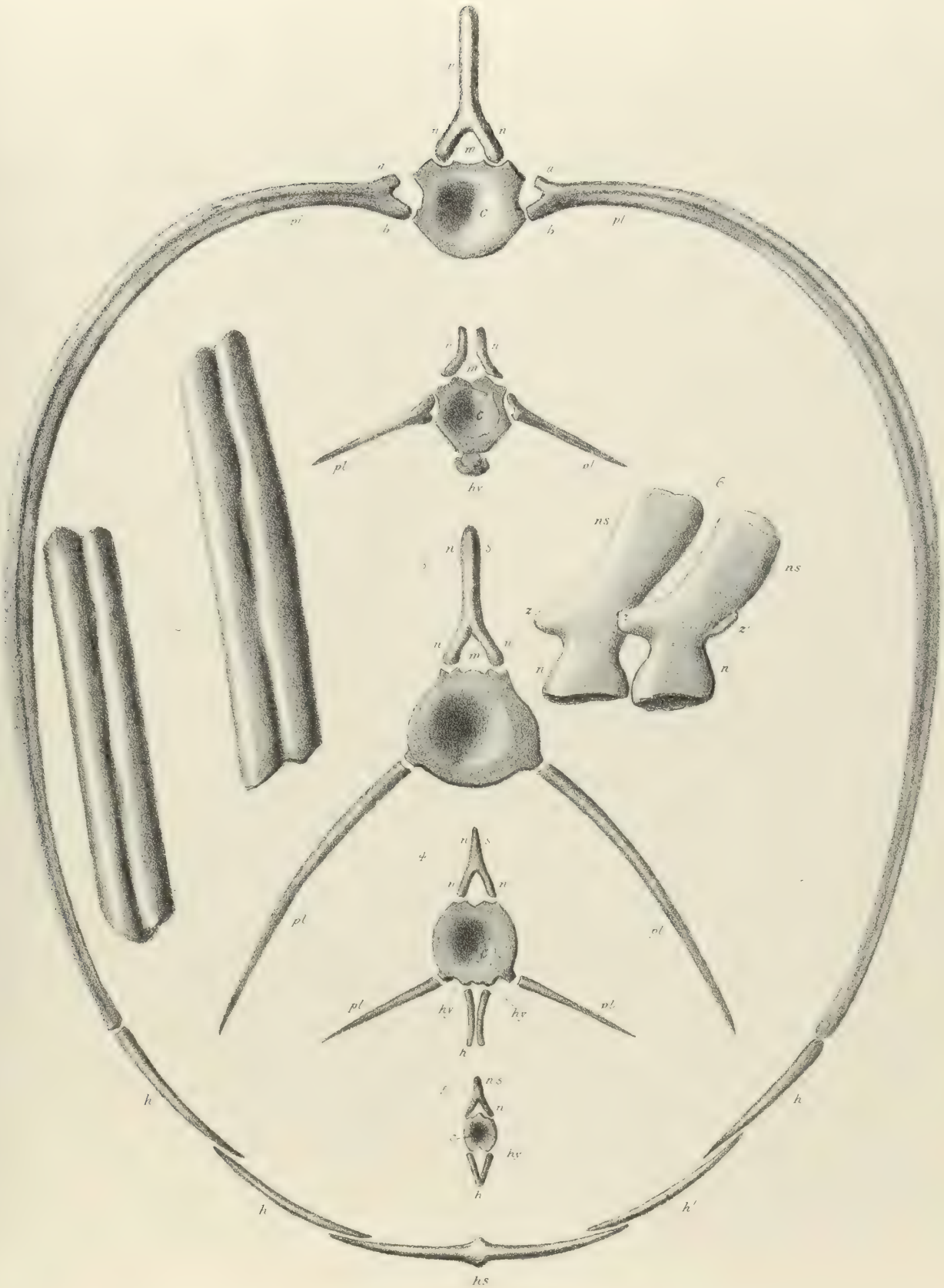
Fig.

1. First or atlas vertebra.
2. Trunk-vertebra.
3. Pelvic vertebra.
4. Caudal vertebra.
5. Terminal or pinnigerous vertebra.

(These figures are less than the natural size.)

6. Neural arches of trunk-vertebræ, side view.
7. Portions of pleurapophyses of trunk-vertebræ, outer side view.

(These figures are of a small specimen, natural size.)



A.Gawan del et lith

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ICHTHYOSAURUS
TYPICAL VERTEBRÆ

PLATE XXII.

Ichthyosaurus.

Vertebral centrums; regional characters.

Fig.

1. Anterior trunk-vertebra, side view.
2. Ib. upper view.
3. Ib. front view.
4. Middle trunk-vertebra, side view.
5. Ib. upper view.
6. Ib. vertical transverse section.
7. Posterior trunk-vertebra, side view (*Ich. latimanus*).
8. Ib. front view (ib.).
9. Caudal vertebra, side view.
10. Ib. under view.
11. Ib. front view.
12. Posterior caudal vertebra, side view.
13. Ib. from base of pinnigerous portion, side view (*Ich. latimanus*).
14. Ib. under view.

(All the figures are of the natural size.)

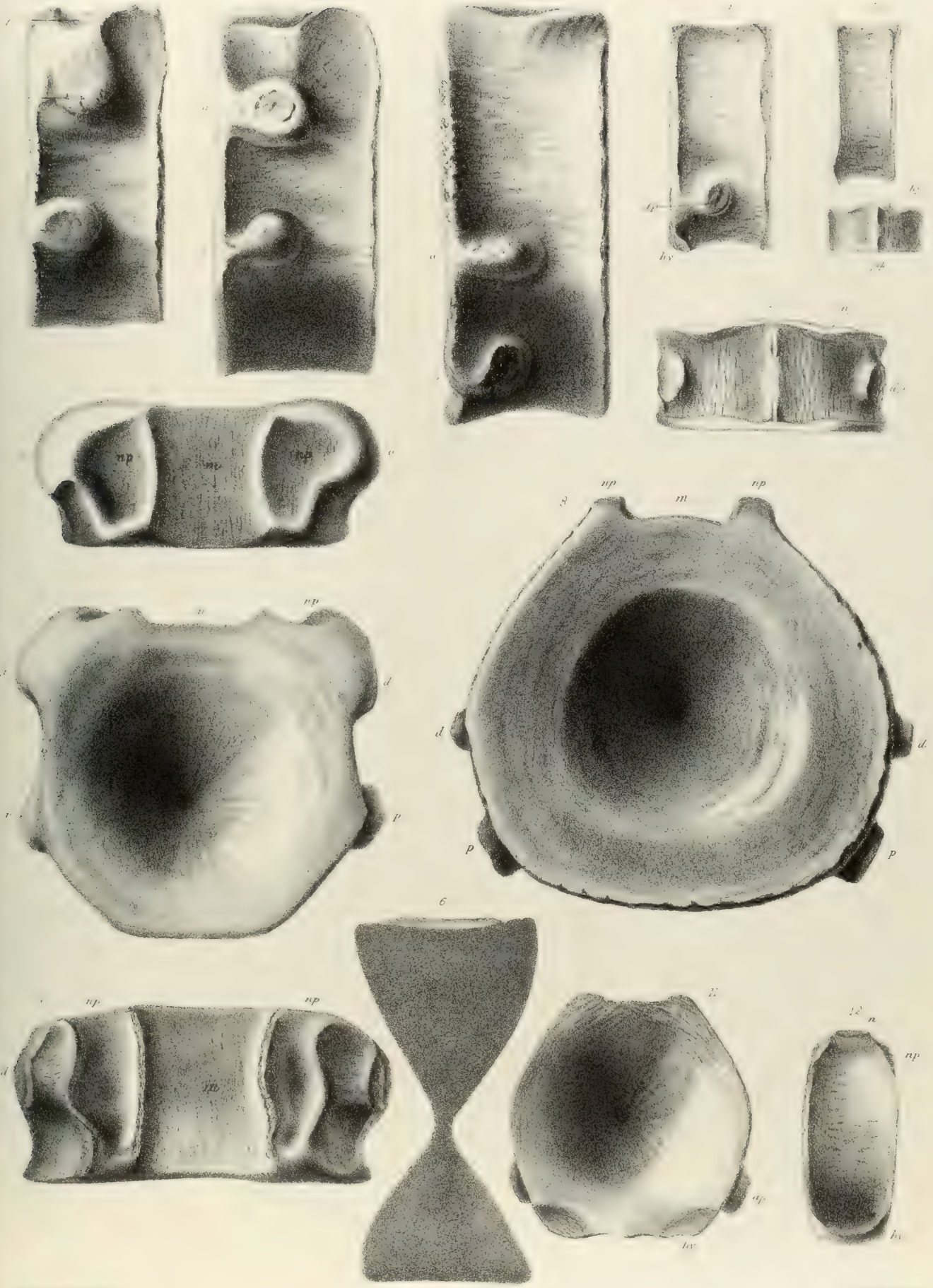
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PLATE XXIII.

Ichthyosaurus.

Cranial and vertebral characters.

Fig.

1. Skull, lacking end of snout, upper view (*Ich. longifrons*, Ow.).
2. Centrum of atlas vertebra, front view (ib.).
3. Ib. upper view (ib.).
4. Ib. back view (ib.).
5. Atlas and axis vertebræ, side view (ib.).
6. Atlas, axis, and third vertebræ, side view (*Ich latifrons*).

Figs. 1—5 are from the Upper Lias.

Fig. 6 is from the Lower Lias.

(All the figures are of the natural size.)

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ICHTHYOSAURUS LONGIFRONS.

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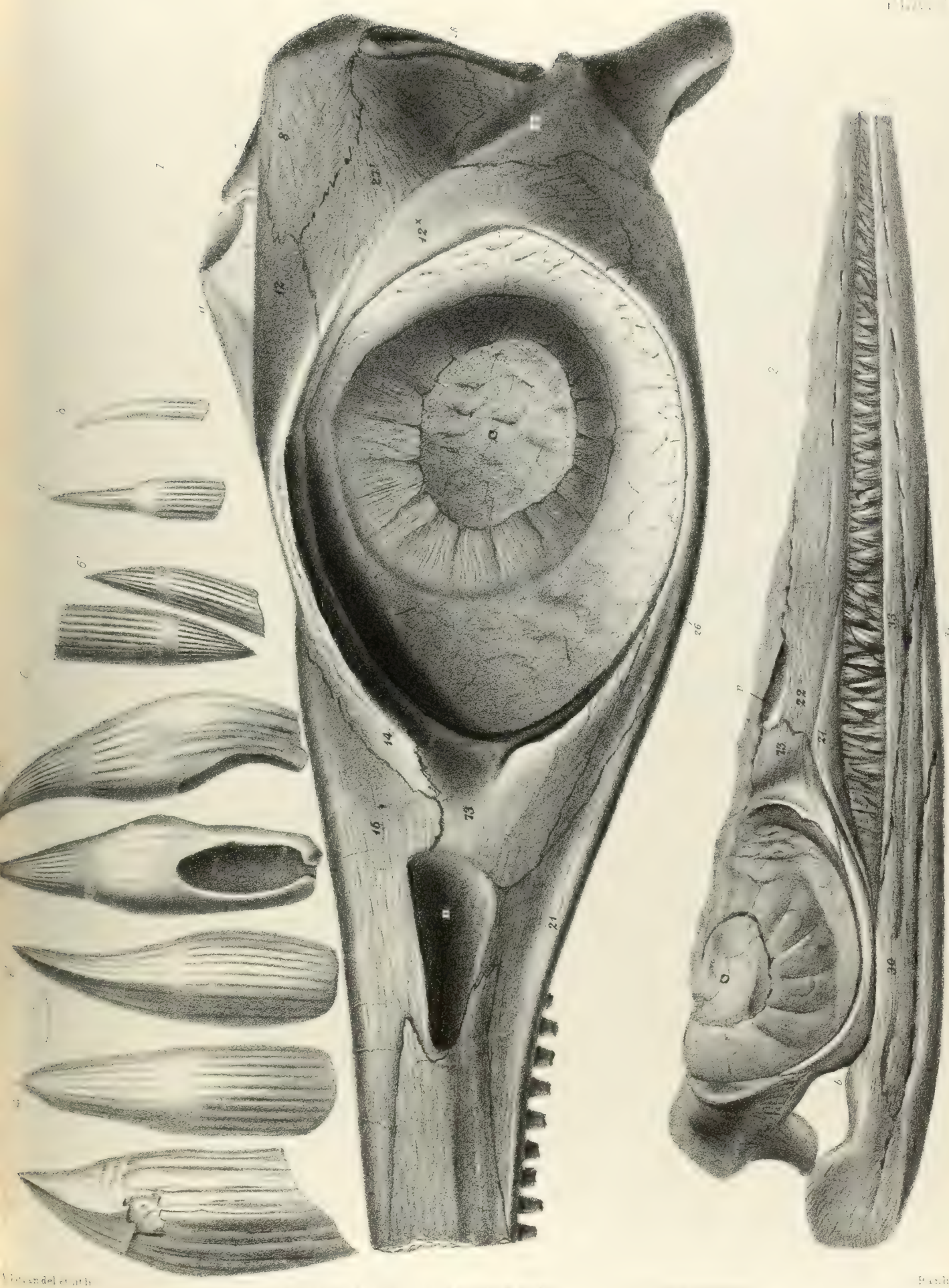
PLATE XXIV.

Ichthyosaurus.

Fig.

1. Skull (lacking end of snout), side view (*Ich. longifrons*).
2. Skull (lacking upper surface), side view (*Ich. communis*).
3. Tooth of *Ich. trigonodon.*
4, 4′. Teeth of *Ich. platyodon.*
5, 5′. Teeth of *Ich. communis.*
6, 6′. Teeth of *Ich. lonchiodon.*
7. Tooth of *Ich. intermedius.*
8. Tooth of *Ich. tenuirostris.*



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Becker imp.

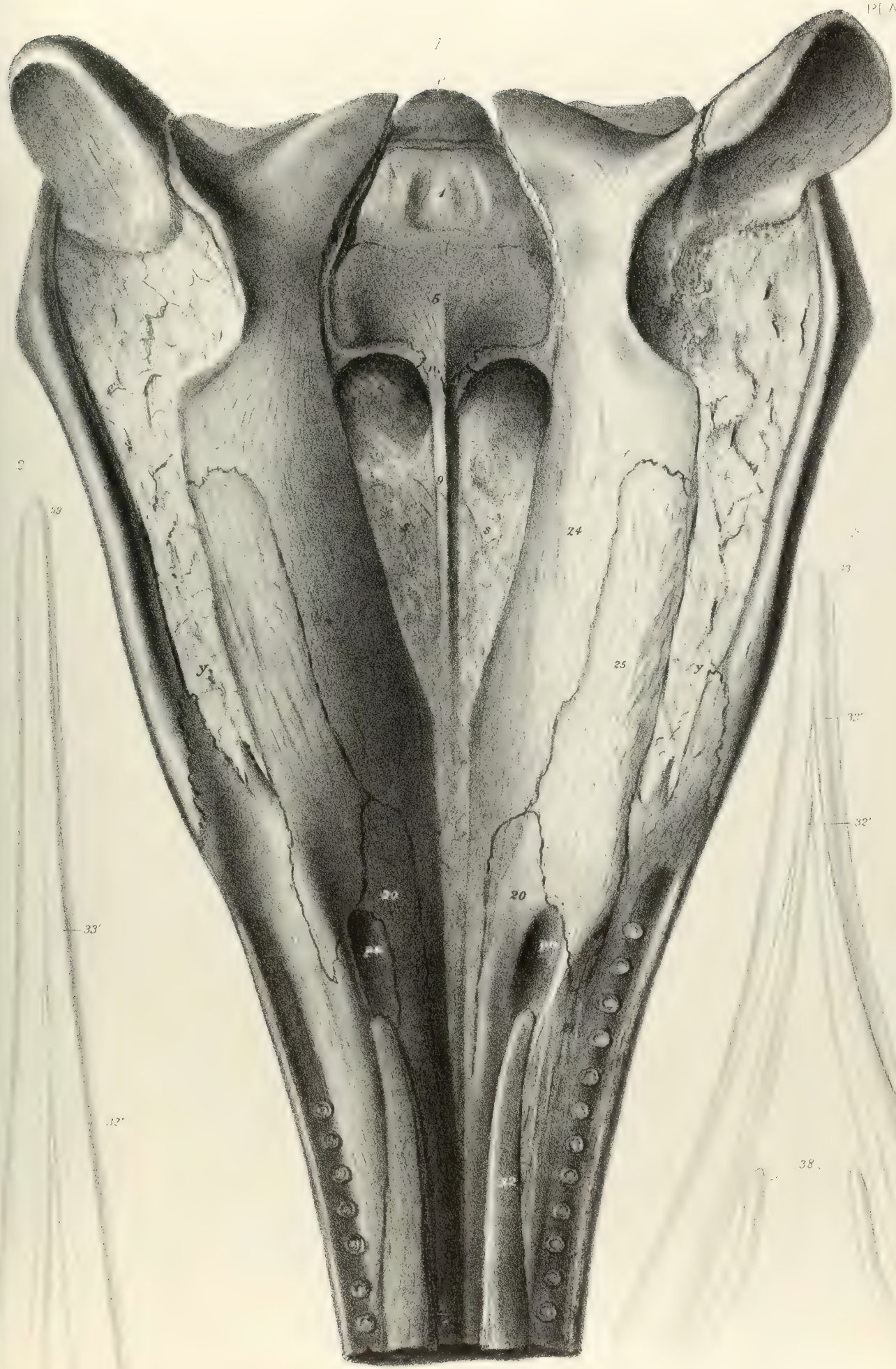
PTERODACTYLE LONGIROSTRE.

PLATE XXV.

Ichthyosaurus.

Fig.

1. Skull (lacking lower jaw and end of upper jaw), base view (*Ich. longifrons*).
2. Outline of lower view of symphysial end of mandible (*Ich. longirostris*).
3. Ib. with hyoid bones (*Ich. tenuirostris*).



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ICHTHYOSAURUS LONGIFRONS 2 ICH LONGIROSTRIS, 3 ICH TENUIROSTRE

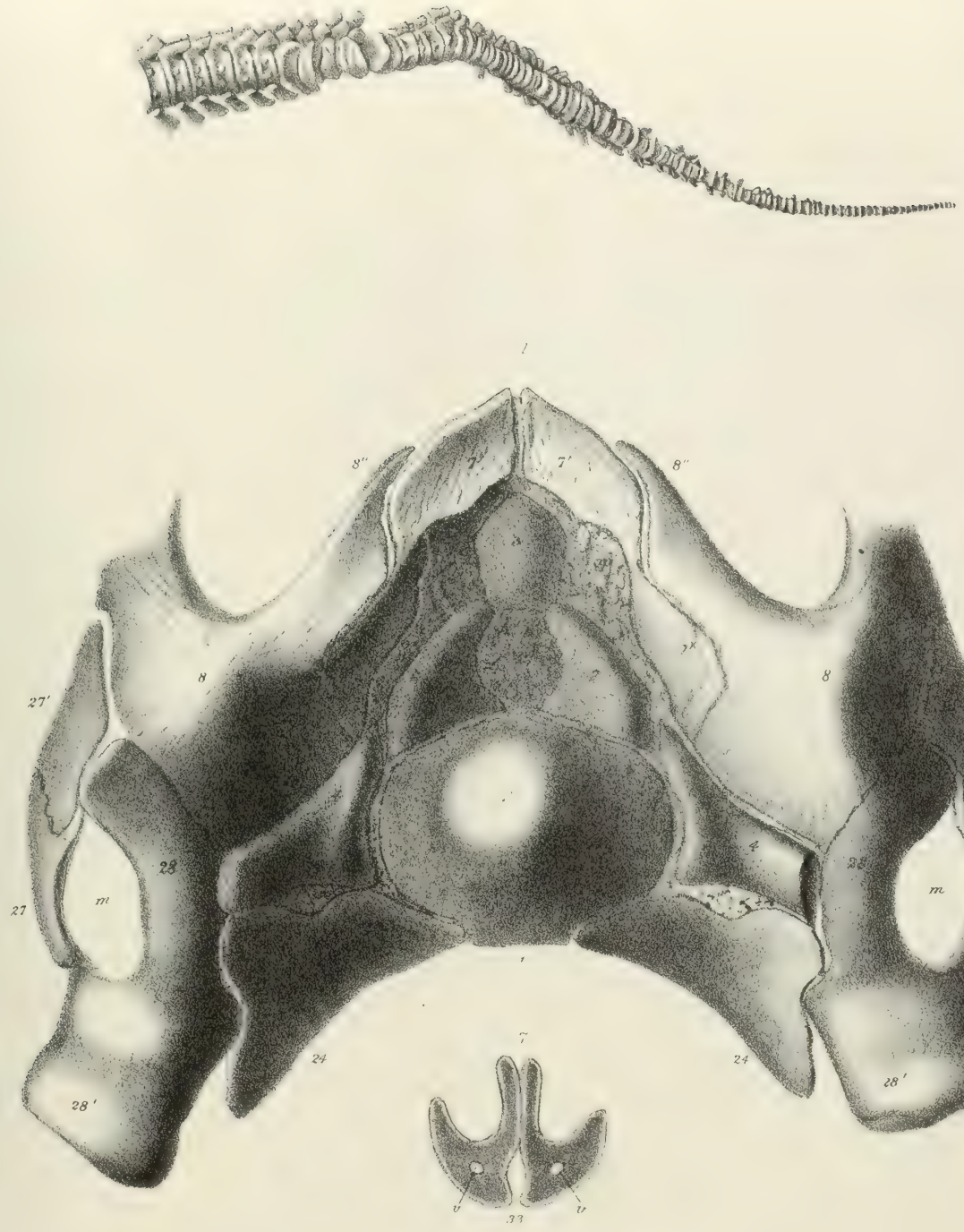
PLATE XXVI.

Ichthyosaurus.

Fig.

1. Skull (lacking the lower jaw), back view (*Ich. longifrons*).
2. Vertical transverse section of hind end of mandibular ramus (*Ich. intermedius*).
3. Ib., somewhat in advance of fig. 2 (ib.).
4. Ib., across the hinder end of the dentary element (ib.).
5. Ib., in advance of the mid-length of mandibular ramus (ib.).
6. Ib., across the anterior end of the surangular and splenial elements (ib.).
7. Ib., near the anterior end of both mandibular rami (ib.).
8. Terminal caudal vertebræ with accidentally deflected pinnigerous end (ib.).

(All the figures save the last are of the natural size.)



A Gawan del. et lith

Hanhart imp

1 ICHTHYOSAURUS LONGIFRONS

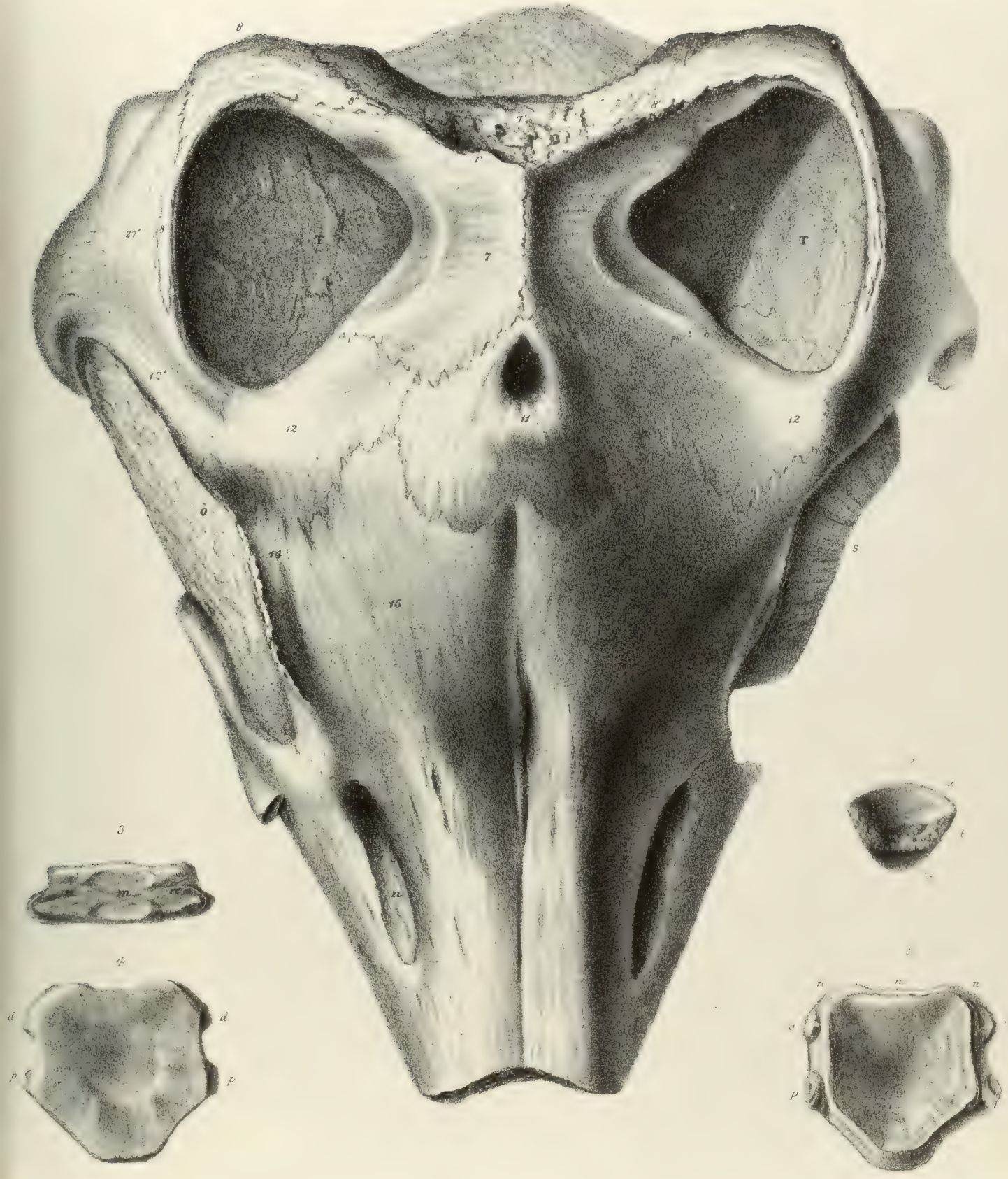
PLATE XXVII.

Ichthyosaurus.

Fig.

1. Skull (lacking end of snout), upper view (*Ich. latifrons*).
2. Hypapophysis or 'wedge-bone' of the atlas vertebra, upper view (*Ich. longifrons*).
3. Axis vertebra, upper view (ib.).
4. Ib., front view (ib.).
5. Ib., back view (ib.).

(All the figures are of the natural size.)



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Hanhart imp

ICHTHYOSAURUS LATIFRONS

PLATE XXVIII.

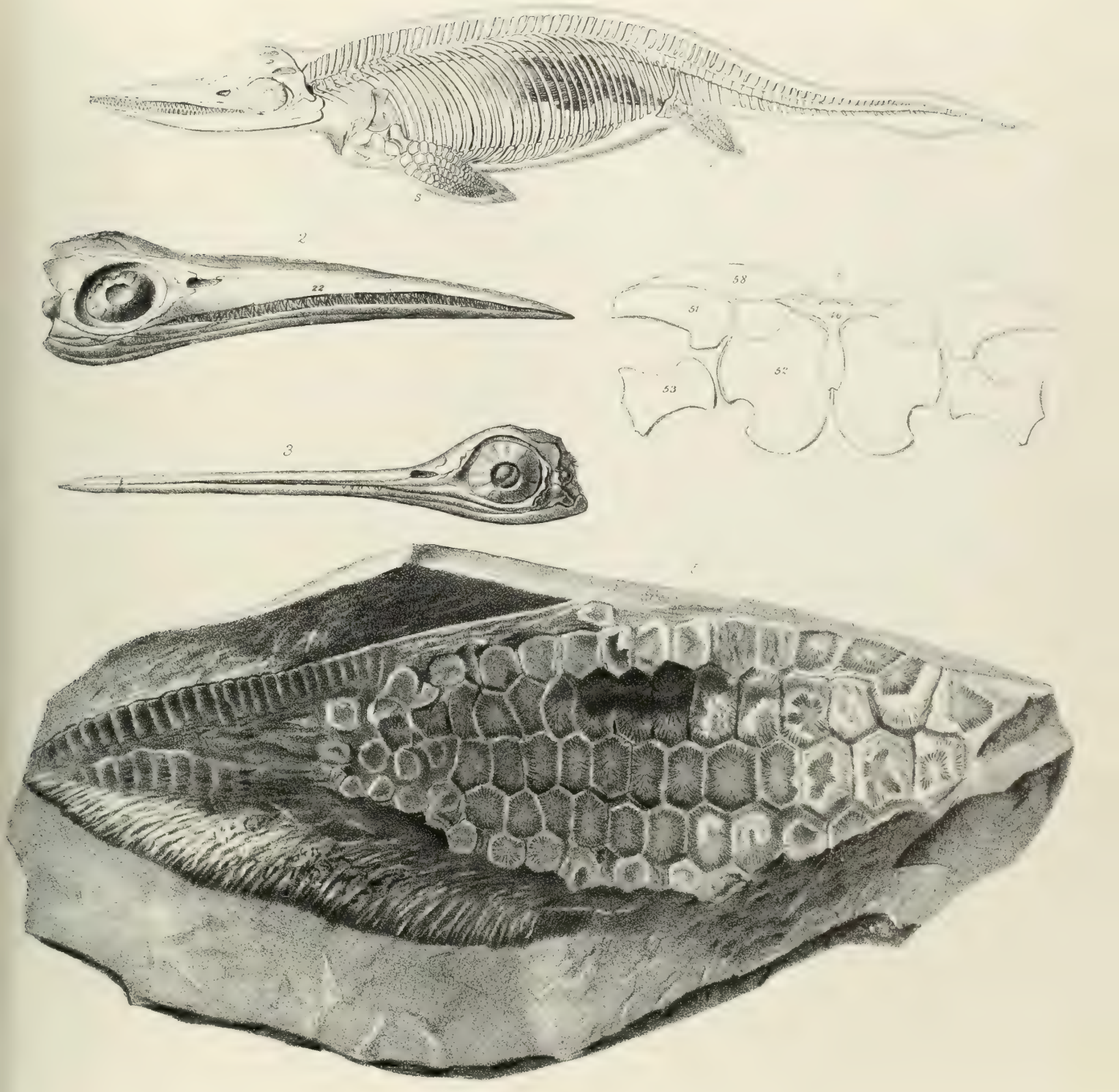
Ichthyosaurus.

Fig.

1. Restoration with skeleton and included fœtus (*Ich. communis*)
2. Skull, side view (*Ich. acutirostris*).
3. Ib., ib. (*Ich. longirostris*).
4. Scapular arches and humeri (*Ich. communis*).

(These figures are more or less reduced.)

5. Slab of Lias, with bones and part of tegumentary sheath of hind fin, nat. size (*Ich. communis ?*).



A.Gawan del et lith

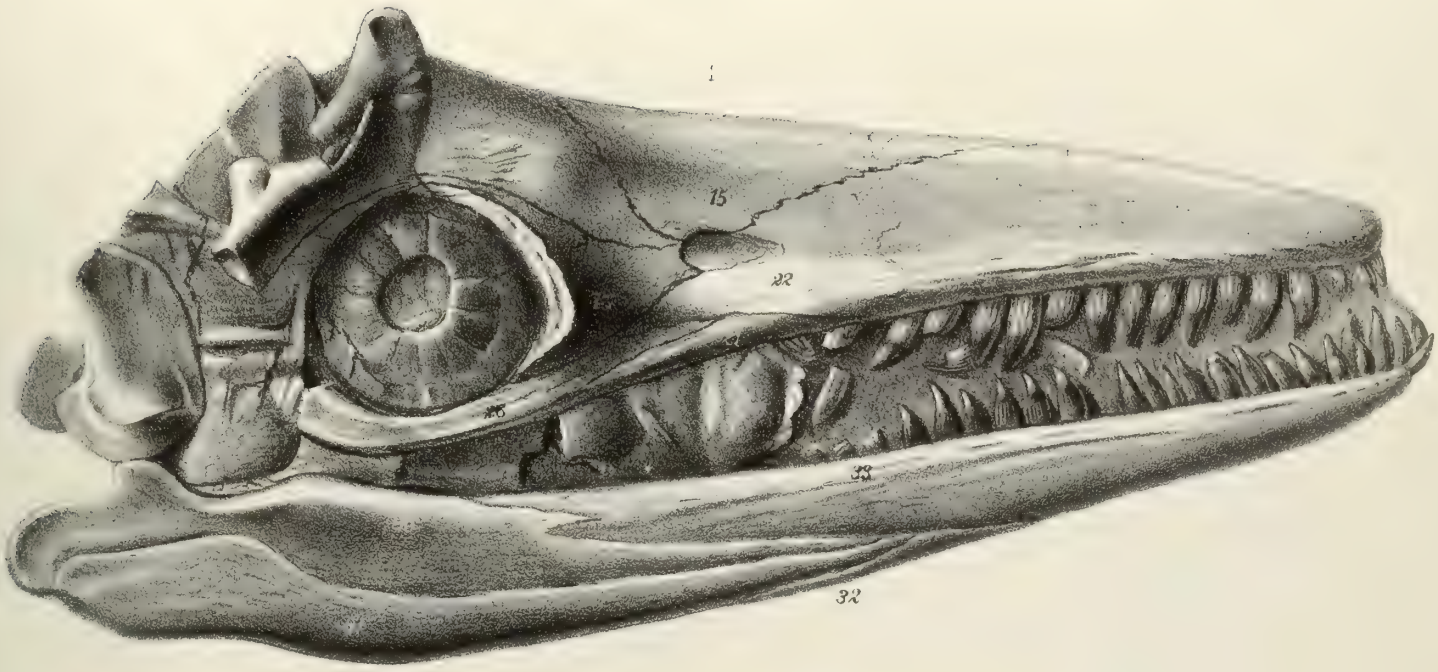
1. ICHTHYOSAURUS COMMUNIS. 2. ICH. ACUTIR

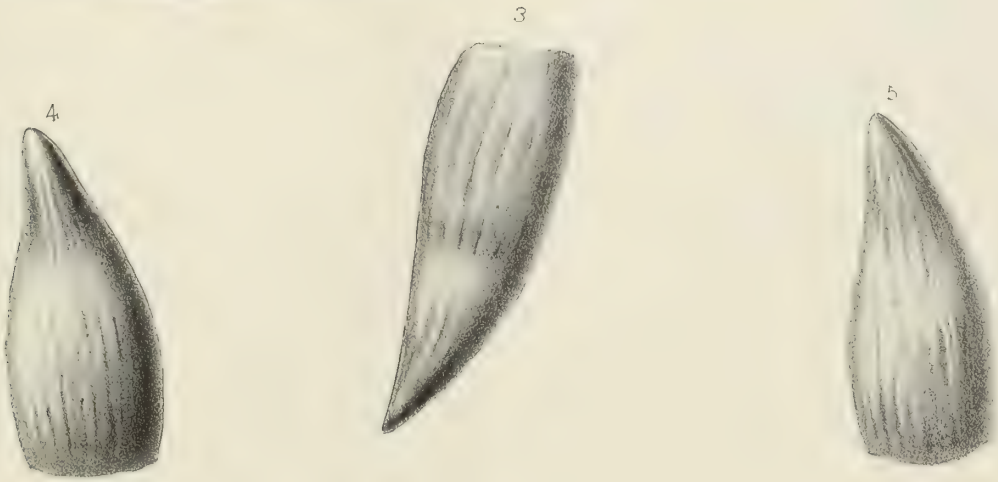
PLATE XXIX.

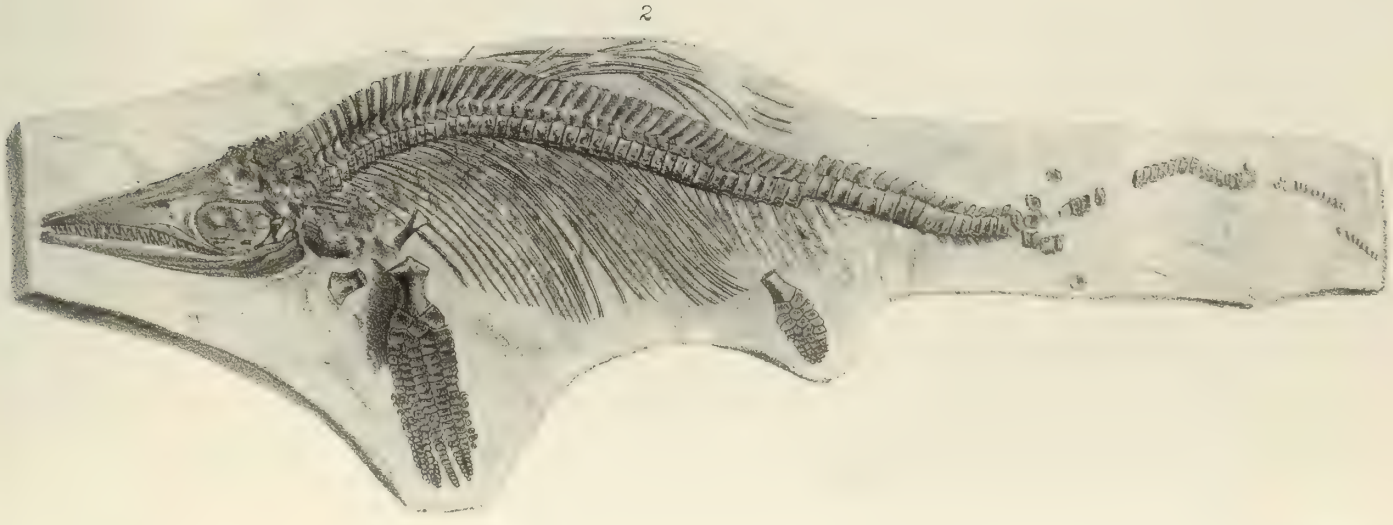
ICHTHYOSAURUS BREVICEPS, *Ow.*

FIG.

1. Skull, side view, $\frac{1}{4}$ nat. size.
2. Skeleton of a younger specimen, $\frac{1}{6}$ nat. size.
3. Tooth from upper jaw of fig. 1, nat. size.
4. Ib. from lower jaw of fig. 1, nat. size.
5. Ib. from hinder part of the series, nat. size.







on Stone by J Erxleben

Hanhart imp

ICHTHYOSAURUS BREVICEPS

PLATE XXX.

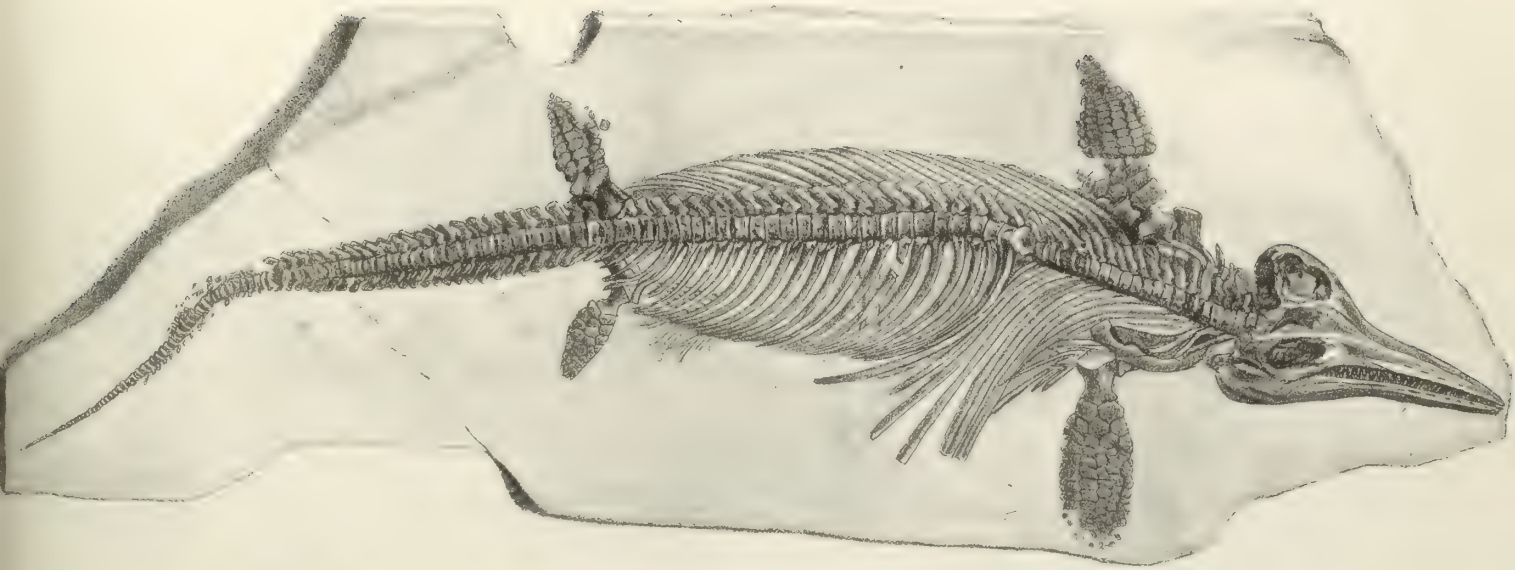
Ichthyosaurus intermedius.

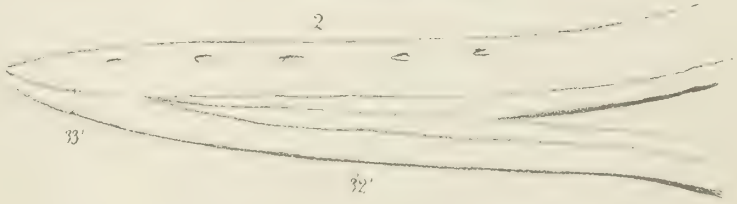
Fig.

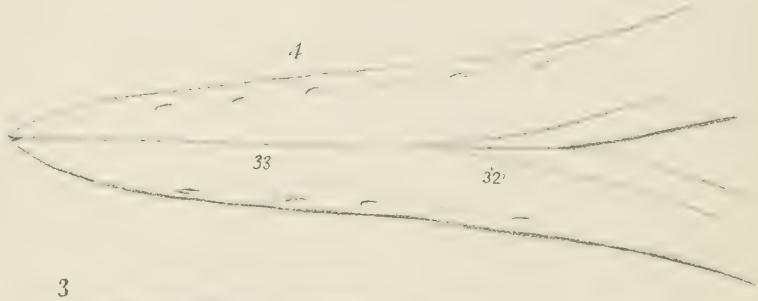
1. Skeleton, from the dorsal aspect, $\frac{1}{8}$ nat size.
2. Symphysis mandibulæ, under view, $\frac{1}{2}$ nat. size.

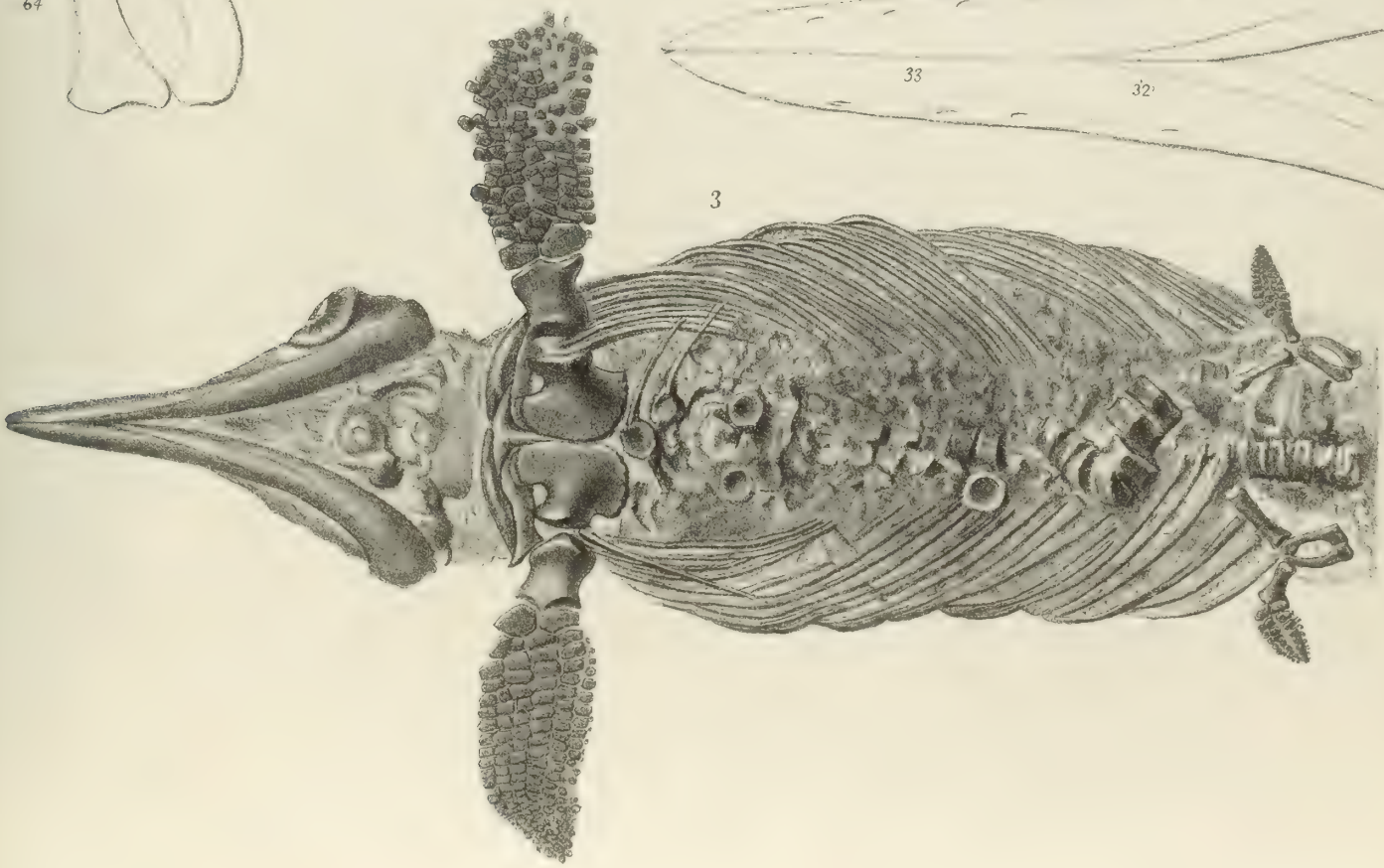
Ichthyosaurus communis.

3. Portion of skeleton, from the ventral aspect, $\frac{1}{7}$ nat. size.
4. Symphysis mandibulæ, under view, $\frac{1}{2}$ nat. size.
5. Bones of pelvic arch, left side, $\frac{1}{2}$ nat. size.









on Stone by J.Erxleben

Hanhart imp

1 & 2. ICHTHYOSAURUS INTERMEDIUS 3.4.5. ICH. COMMUNIS

PLATE XXXI.

Ichthyosaurus.

Fig.

1. *Ichthyosaurus platyodon*, skeleton, dorsal aspect, much reduced.
2. Skull of do., side view, $\frac{1}{10}$ nat. size.
3. Parts of thorax and scapular arch of do., $\frac{1}{12}$ nat. size.
4. Skeleton, *minus* skull, of *Ichthyosaurus lonchiodon*, much reduced.
5. Skull of do., side view, $\frac{1}{10}$ nat. size.
6. Four trunk-vertebræ of do., side view, $\frac{1}{10}$ nat. size.
7. Right coracoid of do, outer view, $\frac{1}{5}$ nat. size.

1–3 ICHTHYOSAURUS PLATYODON; 4–7. ICH. LONCHIODON

PLATE XXXII.

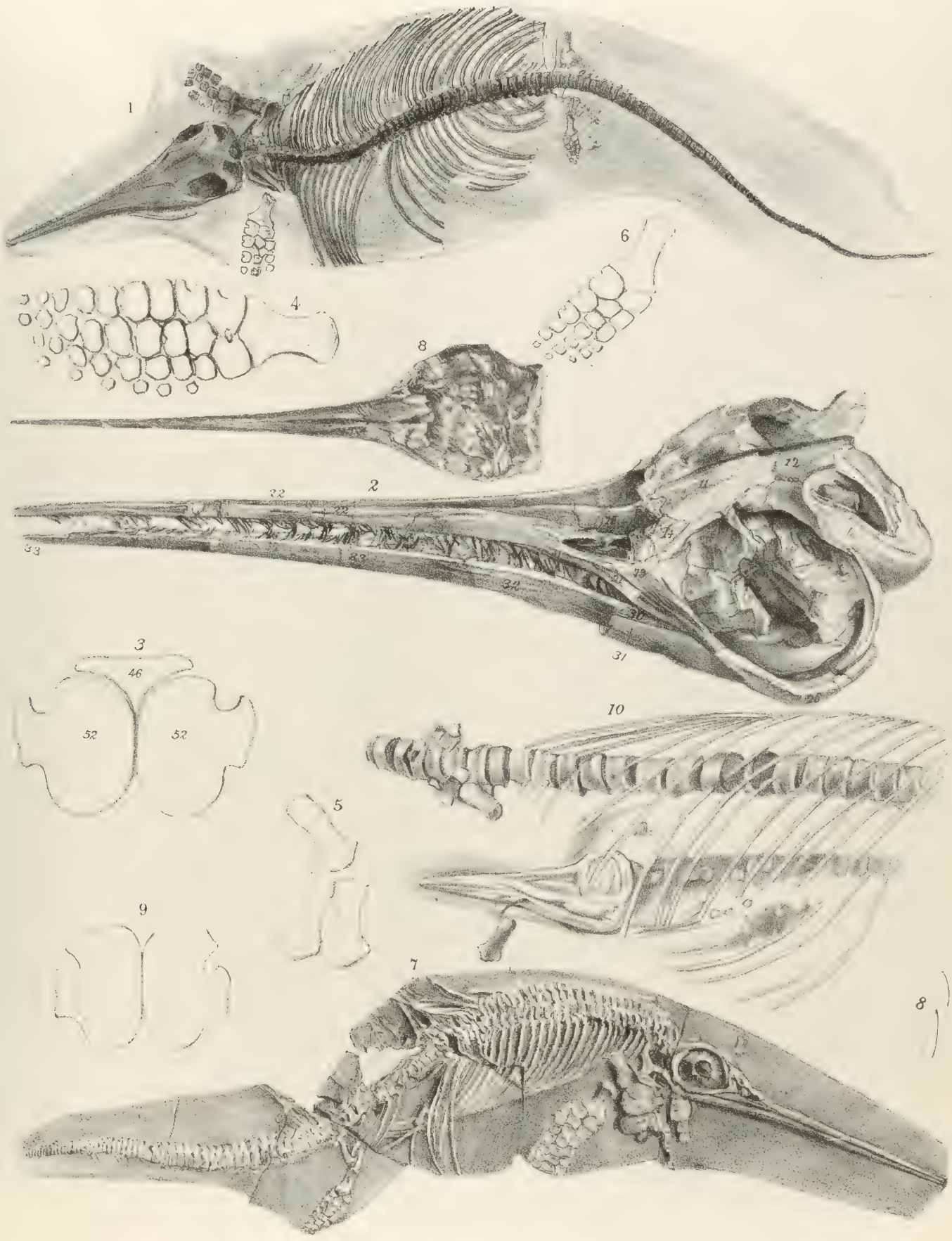
Ichthyosaurus.

Fig.

1. *Ichthyosaurus tenuirostris*, skeleton, dorsal aspect, much reduced.
2. Ib., oblique side view of skull, $\frac{1}{5}$ nat. size.
3. Ib., episternum and coracoids, ib.
4. Bones of pectoral paddle, in outline, 1-6th nat. size.
5. Pelvic bones in outline, ib.
6. Bones of pelvic paddle, in outline, ib.
7. *Ichthyosaurus longirostris*, skeleton, side view, much reduced.
8. Ib., skull, upper view, much reduced.

8′. Ib., teeth, in outline.

9. Coracoids of do., in outline, $\frac{1}{6}$ nat. size.
10. Pelvic part of skeleton, with fœtus, *Ich. intermedius* (after Jaeger).



on Stone by J Erxleben.

Hanhart imp

1–6 ICHTHYOSAURUS TENUIROSTRIS 7–9 ICH. LONGIROSTRIS 10 ICH. INTERMEDIUS

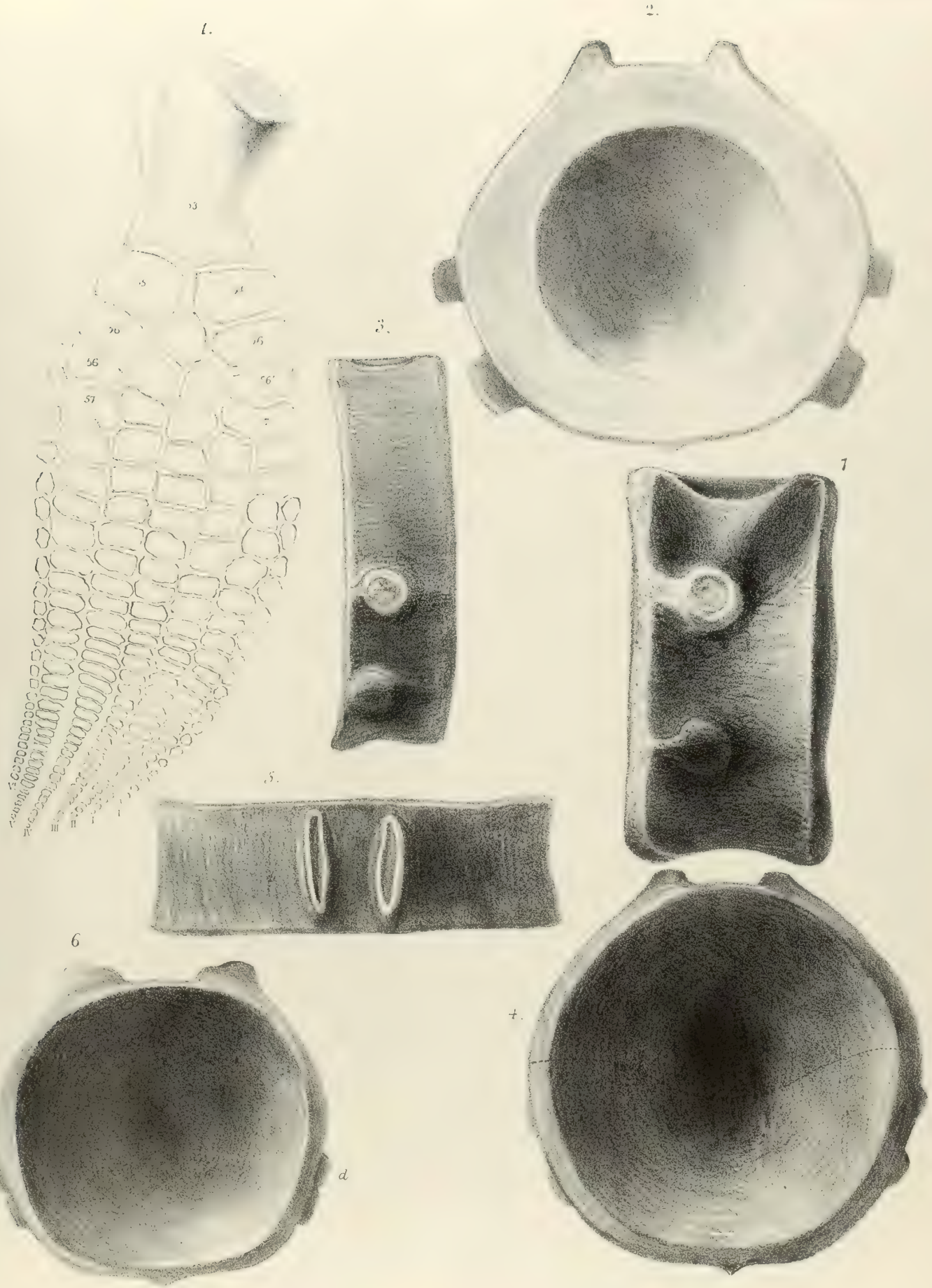
PLATE XXXIII.

Ichthyosaurus.

Fig.

1. Restoration of bones of pectoral paddle, in outline, $\frac{1}{3}$ nat. size.
2. Articular surface of centrum of *Ichthyosaurus latimanus*.
3. Side view of centrum of *Ichthyosaurus brachyspondylus*.
4. Articular surface of do., do.
5. Neural surface of do., do.
6. Articular surface of post-abdominal vertebra of do.
7. Side view of centrum of *Ichthyosaurus latimanus*.

Figs. 2—7 are of the natural size.



1 RECTORAPHE N. T. PADDLE
2 [illegible] LATIMANUS [illegible] ICHTHYOSAURUS BRACHYSPONDYLUS

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1881.

LONDON:

MDCCCLXXXI.

THE BRITISH FOSSIL ELEPHANTS.

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The Monograph on the British Fossil Elephants will be found in the Volumes of the Palæontographical Society issued for the years 1877, 1879, and 1881.

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69—146	VI—XV	1879	May, 1879
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MONOGRAPH

ON THE

BRITISH FOSSIL

ELEPHANTS.

BY

A. LEITH ADAMS, M.A., M.B., F.R.S., F.G.S.,

PROFESSOR OF NATURAL HISTORY IN THE QUEEN'S COLLEGE, CORK.

PART III.

OSTEOLOGY OF ELEPHAS PRIMIGENIUS (*Blumenbach*)

AND

DENTITION AND OSTEOLOGY OF ELEPHAS MERIDIONALIS (*Nesti*).

Pages 147—265; Plates XVI—XXVIII.
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BRITISH FOSSIL ELEPHANTS.

CORRIGENDA AND ADDENDA.

Page 26, line 28, *for* in inches *read* in 6 inches.
,, 47 ,, 12, Table, *for* *x* 9 *x* *read* *x* 8 *x*.
,, 47 ,, 13, ,, *for* *x* 19 *x* *read* *x* 21 *x*.
,, 47 ,, 17, *for* *x* 24 *x* *read* *x* 22 *x*.
,, 57 ,, 3, *after* *E. antiquus* *add* Plate XVII, figs. 2 and 5.
,, 62 ,, 24, *for* more apart *read* more convergent.
,, 71 ,, 35, *for* Alwick *read* Atwick.
,, 76, note 4, *for* care *read* cave.
,, 92, line 6, *for* Hyæna, Horse, Irish Elk, and Rhinoceras, October 6th, *read* with tooth of Ox, 21st October, 1870.
,, 121 ,, *for* Dawson *read* Dowson.
,, 125, Table, under head of *x* 21 *x* lower molars, *for* 1 *read* 2.
,, ,, ,, under head of *x* 24 *x* upper molars, *for* 5 *read* 6.
Plate XII, fig. 2, *for* Penultimate *read* Ultimate.

The Ilford scapula, as compared with that of the Asiatic Elephant, although shorter than the latter, is $6\frac{1}{2}$ inches broader.

The acromion is near to the glenoid cavity in the Asiatic, but altogether there is little of much importance to distinguish the scapula of the Mammoth from that of the Asiatic Elephant, thereby adding an additional proof to the close dental and osteological characters of the two species; and doubtless, were the same parts of other allied species forthcoming, similar interesting data would be furnished.

4. SPINAL AXIS.

The various elements, in particular dorso-lumbar vertebræ of the Mammoth are plentiful in collections, but from their susceptibilities to injury are seldom found entire. The more perfect specimens belong to individuals from the frozen ice cliffs of Arctic lands, or were dredged from the basin of the German Ocean.

Atlas.

This element of the vertebral column of the Mammoth presents characters which, if persistent, would be very valuable in the differentiation of species; but I find, as recorded at page 56, that there is individual variability both in the living and extinct species. However, the following seem worthy of notice. Referring to the atlases shown in Pl. XVII, of the Mammoth, *E. antiquus*, and *E. meridionalis*, I have observed that the foramina for the first cervical nerve in the majority of first cervicals of the Mammoth open internally on the sides of the body, which are perpendicular, so that the apertures are not visible when viewed from above; and the same obtains in that of the Asiatic Elephant generally. I have seen several exceptions, however, in bones of both species. In *E. meridionalis*, *E. Africanus*, and *E. antiquus* it is quite visible from above, so that the internal surface of the canal is less perpendicular in them; but also this character may not be constant. The configuration of the anterior articular surfaces is nearly semilunar, as seen in fig. 1, as compared with that of *E. antiquus* and *E. meridionalis* (figs. 2 and 3). Again, the greater width of the odontoid and vertebral canals in the Mammoth and *E. antiquus* will be seen to contrast with the same in *E. meridionalis*, the height to breadth being not so marked in the two former as in *E. meridionalis*, whilst the flattening of the upper aspect of the arch in them seems distinct from the round surface in the latter. But a series of specimens of the atlases of *E. antiquus* and *E. meridionalis* can only determine these apparent distinctions, which, as regards the Mammoth and Asiatic Elephant, seem disposed to individual variation. The atlas in the Mammoth seldom seems to exceed fifteen to sixteen inches in its greatest breadth, and eight inches in height, both of which measurements fall very short of that of the enormous cervicals of *E. meridionalis*, and often of *E. antiquus*.

A good representation of a small atlas of the Mammoth is shown in Pl. XVII, fig. 1. The specimen is from Ilford,[1] No. 45,025, B. M., and has been described by Davies in the Catalogue of the Brady Collection. The dimensions there given are: height 7·4 inches; breadth 13; neural arch 2 × 2·6 inches in width; odontoid fossa 1·7 × 1·9 in width; length of the body inferiorly 2·5 inches.

The above bone goes hand-in-hand with the other portions of the skeleton of the Mammoth from Ilford, and supports the diagnosis deducible from Davies' description of the teeth of this small-sized race or variety.

What may be considered a fair-sized atlas of the Mammoth is shown by No. 26,233, B. M., dredged on the Dogger Bank, German Ocean. Its dimensions are as follows:

Maximum breadth	15·5	inches.
Maximum height	8·8	,,
Breadth of neural canal	3·5	,,
Height of ,,	3	,,
Breadth of odontoid canal	2	,,
Height of ,,	1·8	,,

Axis.

An axis belonging to the skeleton of a Mammoth found in Shandon Cave, Co. Waterford, Ireland,[2] presents the following dimensions:—Height 8·5; anterior posterior diameter 4·4 inches; vertebral canal 2·4 × 2·3 inches; anterior articular facet 3 × 2·4 inches.

Here, again, the disproportions between the height and breadth of the neural canal in both the Asiatic and Mammoth, and to a less extent in *E. antiquus*, contrast with the same in *E. meridionalis* and *E. Africanus*, which are much alike in these points. As regards the three extinct species, the above characters are shown in Pl. XVII, figs. 6, 5, and 4. The anterior articular surfaces will also be seen to present discrepancies, being ovoid and circular; but, as in the case of the atlas, these may likewise be subject to individual variations; at all events, the distinctions are worthy of notice, and will be reverted to in connection with *E. meridionalis*.

The other cervical vertebræ, of which there are several British and Arctic specimens in the British Museum, do not appear to present any characters at all useful for diagnostic purposes. As regards size, like the other bones, they are small in comparison with the same parts in *E. meridionalis* and *E. antiquus*.

[1] $\frac{c}{93}$, p. 16.

[2] Adams' "Report on the Shandon Caves," 'Trans. Roy. Irish Acad.,' vol. xxvi, p. 214. This specimen, along with the other portions of the skeleton, is preserved in the Museum of Science and Art, Dublin.

Dorso-lumbar Vertebræ.

The first dorsal vertebra (Pl. XVII, fig. 7) was dredged off Lowestoft, Suffolk, and is in the possession of J. J. Colman, Esq., M.P., of Corton, who has kindly furnished me with an excellent photograph of this entire specimen. It would be difficult to say with accuracy to which of the three species it belonged; the probability is, however, in favour of its being a first dorsal of the Mammoth, seing that in characters and size it agrees with similar authenticated specimens from British and Arctic deposits. The total height is 20 inches. Height of spine and neural canal 14 inches; spine, from neural canal to apex, 11·5 inches; total breadth 13·5 inches. Height of centrum 6 inches; breadth of centrum 6·5 inches; thickness 3 inches. Neural canal 3 × 4·8 inches in width.

A first dorsal vertebra, presumably belonging to the same individual as the axis just described from Shandon Cave, is 13 inches in height by 11·5 in its greatest breadth. The vertebral canal is 2·4 inches in height by 3·5 inches in width. These two specimens pretty well indicate the dimensions of the bone in the Mammoth. As regards the Asiatic and African Elephants, the contour of the neural canal approaches closer to the former. I have no data wherewith to compare the above with the same part in the other two extinct Elephants, seeing that in them the arches are rarely sufficiently preserved to admit of comparison.

A third dorsal vertebra of the Mammoth, in the British Museum, from Admiral Kellet's Collection, made in Eschscholtz Bay, Arctic America, is nearly entire, excepting the loss of the neural apophysis, which had not been anchylosed to the spine, and therefore belonged to an adolescent individual.

The height is 20 inches; maximum breadth 10 inches. Centrum, 4·5 × 4·4 inches in the transverse diameter.

The neural canal is similar to that of fig. 7.

A posterior dorsal in the same Museum, from Kotzebue Sound, Arctic America, had belonged to a youthful individual, as the anterior and posterior surfaces of the centrum are without the epiphyses, and the neural spine is wanting.

The entire length is 18 inches; maximum breadth 10 inches. Centrum 4 × 4·4 inches. The canal is 1·9 × 2·4 inches; thickness 2·1 inches.

There are centra and portions of other dorso-lumbar vertebræ in the British Museum and elsewhere, but none seem worthy of particular notice, as they present no diagnostic characters of importance, only that they are small as compared with Forest-Bed specimens referable to *E. meridionalis* and *E. antiquus*, as will appear in the sequel.

The *ribs* and *sternum* are represented by fragments in the British Museum, none of which, however, are sufficiently entire to be useful for diagnostic purposes.

5. PELVIC GIRDLE.

The relative dimensions of the pelvic borders do not seem to offer any very reliable data, either in the recent or the extinct species. The following details, however, are worth recording.

1. As indicated by Cuvier, Busk, and myself,[1] the proportion between the length and breadth of the *foramen ovale* is greater in the Mammoth than in either of the recent Elephants. This is well seen in various Arctic examples of the former and specimens of the latter. Moreover, the smaller end of the oval is superior in the Asiatic, Mammoth, and Meridional, and the channel for the nerve more pronounced, indeed, in some it is almost a foramen; whilst the broader end of the oval is superior, and the groove small, in the African. I have not seen a pelvis of the Ancient Elephant.

2. The acetabulum in eight examples of the Mammoth from the Arctic region shows the vertical to be the largest measurement, whereas in the recent species, and also one of *E. meridionalis*, it is shorter than the transverse.

3. As far as detached *ossa innominata* of the Mammoth are concerned, I am unable to show any marked distinctions of the antero-posterior to the lateral diameters as compared with the two recent species, and leastwise in the huge pelvis in the Gunn Collection referred to by Falconer,[2] which I compared carefully with the same bone in recent species.

4. The cotyloid notch in the Asiatic Elephant and the Mammoth opens on a flat surface, which is absent in the African to the extent that the notch opens directly on the upper and outer border of the *foramen ovale;* moreover, it is wider generally in the Mammoth and Asiatic than in the *acetabulum* of the African.

5. I find that the *obturator* border of the *ischium* is narrower and the internal spine of the latter more pronounced in the Mammoth and Asiatic than in the African; moreover, as far as the somewhat injured parts of the huge pelves from the East Coast are concerned, they seem to follow the two former in their characters.

The following data may be cited in connection with the pelvis of the Mammoth. In the Kellet and Beechy Collections there are several portions of the pelvic basin from Eschscholtz Bay and other Arctic regions, presenting the following:

Specimen 1 shows the same contour of the *foramen ovale* as in the Asiatic. The *acetabulum* is $6{\cdot}5 \times 6{\cdot}3$ inches in breadth. The width of the neck of the *ilium* is 8 inches.

The gaping cotyloid notch opens on a flattened space.

[1] 'Ossem. Fossil.,' vol. ii, 221, pl. xvi, figs. 1 and 2. Busk, 'Trans. Zool. Soc. London,' vol. ix, p. 49. Adams, p. 61, *antea*.

[2] 'Pal. Mem.,' vol. ii, p. 142, figs. 1 and 2.

Specimen 2. The *acetabulum* is $6 \times 5\frac{1}{2}$ inches; width of the neck of the *ilium* 8 inches.

Specimen 3. Repeats the two former.

Specimen 4. Maximum breadth of *ilium* 33 inches.

Width of neck of ditto 7 „

The sciatic notch is here so deep as to form almost a foramen at the upper end of the oval.

The *acetabulum* is $6 \times 5\frac{1}{2}$ inches.

Specimen 5 includes the *sacrum*, with five anchylosed vertebræ; its lumbo-articular surface is $4\frac{3}{4}$ in a. p. diameter, by $6\frac{3}{4}$ inches in the transverse diameter.

In the Owles Collection, B. M., from the Dogger Bank, there are several fragments. No. 46,268 has an *acetabulum* $7 \times 6\frac{3}{4}$ inches, with a nearly complete sciatic notch. No. 46,267 has the *foramen ovale* $9\frac{3}{4} \times 4$ inches, whilst the *acetabulum* is $7\frac{1}{2} \times 7\frac{1}{4}$. In this bone the *foramen ovale* and cotyloid notch are as in the Asiatic.

The Brady Collection from Ilford furnishes also further data, viz., $\frac{C}{180}$. *Acetabulum* $6 \times 5{\cdot}6$ inches. *Foramen ovale* 6 (height), $3\frac{1}{4}$ (breadth). No. $\frac{C}{181}$. *Acetabulum* $6 \times 5{\cdot}6$.

A right *os innominatum* of *E. primigenius*, in the Gunn Collection, Norwich Museum, dredged off Yarmouth, has the *foramen ovale* 7×3 inches.

The pelvis, No. 2744 E, of an enormous Asiatic Elephant in the Museum of the Royal College of Surgeons of England is portion of a skeleton of, perhaps, one of the largest individuals hitherto brought to Europe. The humerus is referred to at pages 59, 153 and 215, and shown in Plate XVI, fig. 4, and the femur at page 164. The perfection of the *ossa innominata*, which are completely anchylosed at the pubic symphysis, offer some excellent measurements in comparison with the pelvic elements of the extinct species, more especially the huge bones of *E. meridionalis*, from the Forest Bed in the Norwich Museum. These are as follows:

1. From the anterior superior spine of *ilium* to the *symphysis pubis* is $24\frac{1}{2}$ (linear), and 27 inches by tape along the margin. In No. 225, *E. meridionalis*, Gunn Collection, Norwich Museum, the former is 34 inches.

2. From anterior superior spine of *ilium* along the upper border to the *sacro-iliac symphysis* is 28 inches (linear), 33 by tape. In No. 225, Gunn Collection, the former is 48, and the latter 67 inches.

3. Height from brim of *acetabulum* to the anterior superior spine of *ilium* 13 (linear), 15 by tape. In No. 225 these two are 18 and 21 inches respectively.

4. Girth of neck of *ilium* $19\frac{1}{4}$ inches. In No. 225 it is $29\frac{3}{4}$ inches.

5. *Pubic symphysis* to *sacrum* 18 linear, round the basin 23 inches. In 225 the former is 20 inches, latter 26 inches.

6. Maximum breadth of *ilium* 16 inches. In 225 it is 25 inches.

7. *Sacro-iliac symphysis* 14×9 inches.

8. Depth of the *pubic symphysis* 18 inches. It is 15 inches in No. 225, therefore less than in the Asiatic.

9. *Acetabulum* $6 \times 6\frac{1}{4}$ (linear), by tape along the floor of the cup $8\frac{1}{2} \times 7\frac{1}{2}$ inches. In 225 it is (linear) $8{\cdot}5 \times 9$. The wide notch and flattened portion in front are pronounced.

10. *Foramen ovale* $6 \times 4\frac{1}{2}$ inches. In 225 it is $10{\cdot}5 \times 7$.

11. Girth of *pubis* midshaft $8\frac{1}{2}$ inches.

12. Girth of *ischium* midshaft 9 inches. In No. 225 it is 12 inches.

6. HUMERUS.

Cuvier states that the humerus of the African is more slender than that of the Asiatic Elephant, whilst De Blainville asserts that the long bones generally are stouter and shorter than in the Elephant of Asia. Moreover, these two authorities further differ in opinion as to the degree of saliency of the supinator ridge, Cuvier stating that it is *less*, and De Blainville *more*, salient in the African as compared with the Asiatic. They agree that the bicipital groove is *narrower* and the deltoid crest not *so low down* in the Asiatic as in the African. The values of these characters seem, however, questionable, owing to the absence of sufficient instances of the skeleton of the latter in collections in comparison with bones of the former. The abundant materials relating to the Asiatic Elephant appear to me to show considerable inconstancy as regards the stoutness of the limb bones, more especially specimens from both Continental India and its islands. The "slender built" Sumatran Elephant contrasts with the "squat built" form of Central India, and are known by distinct designations.[1] The Central Indian Elephant is smaller than Ceylonese and sub-Himalayan. The same is reported of the Burmese and Siamese, which are said to be still smaller and shorter varieties, whilst some are tuskless. According to travellers there is considerable variability in the size of the African Elephant in different districts.[2]

1. As to the deltoid crest, it seems to me often difficult to exactly define its limits excepting on bones of aged wild individuals. (Pl. XVI, figs. 4 and 5.)

2. The head and tuberosity in two specimens of the African Elephant appear more compressed in the African than in any instance of that of the Asiatic examined by me.

3. With reference to the breadth and depth of the bicipital groove. It is shallow and open in the African (708H), and also in the humerus of a skeleton in the Royal College of Surgeons of Ireland, whereas it is very generally deep and narrow (almost tubular in certain instances) in the Asiatic, but there are exceptions, of which I have notes of two

[1] Falconer, op. cit., vol. ii, p. 257. Tennent's 'Ceylon,' vol. iv, p. 291.

[2] Livingstone, 'Travels in South Africa,' p. 562, and 'Last Journals,' vol. ii, p. 29, where he alludes to a dwarf race averaging 5 feet 8 inches in height with a tusk 6 feet in length.

instances where the groove was fully as open as in the African. Looked upon, however, generally, the above is fairly reliable in the diagnosis of the two species.

4. As to degrees of saliency of the supinator ridge; individual instances in the Asiatic appear precisely to accord with 708H of the African. The ridge was less salient in many instances of the former, but here again there seems so much variability that one is not disposed to place much reliance on this character. Compare fig. 4 with 5.

5. The ridge proceeding from the supinator upwards and backwards to the epiphysis, is very often so pronounced in the Asiatic as to form a carina at its upper part, and would be of value if invariably persistent, but it is not so, being sometimes, as in 708H African, lost before it reaches that point. Compare fig. 4 *a* with 5 *a*.

6. As to the position of the nutritive foramen, when *one* is present and of conspicuous size to entitle it to be considered the main opening, there appears considerable inconsistency as to its exact position in the Asiatic Elephant, but when at all pronounced it is usually in a line with the apex of the supinator ridge, whereas in 708H it is in the lower third. In fossil specimens it is so frequently obliterated by mineral infiltrations as to be quite undiscernible; moreover, the multiplicity of these canals on various parts of the shaft, and their agreement in size, make it uncertain which to rely upon as the normal condition.

7. With reference to the configuration of the distal articular surface, the following points are referred to by Busk,[1] which, if persistent in the African, as they are in all adult humeri of the Asiatic I have examined, would be invaluable in establishing specific characters. These refer to the (*a*) contours of the outer condyle; (*b*) the configuration of the arc formed by the lower border of the articular surface; and (*c*) the contour of the trochlear depression posteriorly, as shown in his monograph referred to on the Maltese fossil Elephants.[1]

The above characters are, viz.:

(*a*) A more globose margin and general contour of the external condyle in the African. This is pronounced in 708H, whereas the same parts are less rounded in the Asiatic. Compare fig. 5 *b* with fig. 4 *b*.

(*b*) The arch of the lower border formed when the humerus is placed erect on a level surface is shorter and nearly central in the African, whereas in the Asiatic it commences gradually from the margin and extends from nearly one to the other. Compare fig. 5 *b* with fig. 4 *b*.

(*c*) The trochlear depression below the pit is narrow in the Asiatic, with nearly perpendicular sides, whereas it is shallow in the African, with gently undulating margins, in fact, as in the case of the bicipital groove, the one is deep and narrow, and the other broad and shallow. Compare fig. 4 *b* with 5 *b*.

8. The depth of the olecranon pit and the hollow surface above it are seemingly greater in 708H African than I have seen in the Asiatic. These, however, may be con-

[1] 'Trans. Zool. Soc. London,' vol. vi, p. 257.

sidered of little value, and are apparently subject to variations in connection with individuals, and perhaps age. Compare fig. 5 *a* with 4 *a*.

9. The internal condyloid ridge is narrow and prominent in 708H African, whilst, as far as I have observed, in all humeri of the Asiatic it is blunt and rounded. This character, from its apparent constancy in the latter, seems to me trustworthy. Compare fig. 5 *a* with 4 *a*.

The magnificent collections of Mammoth remains in the British Museum from British and Arctic localities are rich in specimens of arm-bones, a few of which are entire. The small race which frequented the Thames Valley during and prior to the deposits of the brick-earths of Ilford, as shown by the teeth, pectoral girdle, and axial elements just described, is maintained by the humerus and other portions of its skeleton; whilst, on the other hand, even in the same situation and elsewhere in the neighbourhood, and throughout the islands, we find a larger race differing only in minor morphological characters. Reverting to the Mammoth of Ilford, with reference to what has just been enumerated in connection with races of the Asiatic and African species, it is interesting to observe the same tendencies to variability in the case of the species now under consideration, but with this exception apparently—that whilst the characters of the recent race are general to the individuals frequenting a particular district, in the case of the Mammoth, we find at Crayford and in the neighbouring localities around Ilford remains ascribable to the typical skeleton of the species. But this anomaly may be more apparent than real, seeing that the ages of the strata in which they are found cannot be calculated or distinctly correlated with the adjacent fluviatile deposits.

The arm-bone of the Mammoth is represented in the above-mentioned collections in the British Museum by no less than nineteen, specimens, for the most part fragmentary, but all are suggestive as regards the age and dimensions of their owners. The best preserved specimens, No. $\frac{C}{128}$ of the Brady Collection, is stated by Davies to have been "that of a young individual," but after a careful re-examination of the bone he quite agrees with me that from the fact that the epiphyses are firmly united and not a trace of the union is visible either at the proximal or the distal extremities, there can be no doubt but that it belonged to an adult individual. It is rivalled by another, but less perfectly preserved, specimen, No. $\frac{C}{130}$, which is 27 inches in length, the former being 28·7. The chief dimensions of $\frac{C}{128}$ are given in table at page 215.

The following characters of the arm-bone of the Mammoth, as compared with what have been just stated of the humeri of the two recent species, I shall now indicate.

1. The bone (Plate XVI, fig. 1) altogether is more robust than that of either of the living species, and this stoutness relates more particularly to the relatively larger deltoid crest and the antero-posterior diameter of the upper or proximal third, a feature

altogether more pronounced than in the latter, in fact, a larger expanse for muscular insertions. This character, as far as some fifty humeri of the Mammoth extend, seems to be invariable. Even the superb humerus in Plate XVI, fig. 4 and 4 *a*, of the Asiatic Elephant represents a more slender upper third as compared with the shorter bone of the Mammoth, figs. 1 and 1 *a*.

2. The antero-posterior to the transverse diameter of the head (fig. 1) is 170 to 127 millimètres. The deltoid crest is broad (fig. 1 *a*), and bulges conspicuously outwards about its middle, more so a great deal than I have seen in either of the living, even in that huge bone of the Asiatic (fig. 4), which represents an aged individual said to have died in its native haunts.

3. The bicipital groove is deep and narrow, being $1\frac{1}{2}$ inches in its greatest breadth.

4. The supinator ridge (fig. 1) is not so salient as in the African (Plate XVI, fig. 5), and it is altogether shorter.[1]

5. The posterior ridge proceeding from the supinator ridge to the head, as in the African, and not unfrequently in the Asiatic, although not always clearly traceable, is pronounced in fig. 1 *a* to the proximal articular surface, as in the Asiatic humerus (fig. 4 *a*).

6. The contours of the outer condyle, lower border, and trochlear depression of the distal articulation (fig. 1 *b*) are much as in the Asiatic. These characters I have found very general in all undoubted humeri of the Mammoth which have come under my notice. Compare fig. 1 *b*, Mammoth, with fig. 4 *b*, Asiatic, and fig. 5 *b*, African, also with fig. 6 *b*, *E. antiquus*, and fig. 3 *b*, *E. meridionalis*.

7. The internal condyloid ridge (fig. 1 *b*) is relatively broader than that of the Asiatic Elephant (fig. 4 *b*), and therefore widely different in this respect from the African (fig. 5 *b*).

There are other humeri of considerably larger dimensions in the above Collection (Brady), such as $\frac{C}{126}$, the extreme length of which is 32·5 inches, and another, $\frac{C}{127}$, 33· inches.

I have selected the foregoing as a good typical example illustrative of the humerus of the Mammoth. It is No. 30,531, B. M., and is interesting as being the most westerly indication of the Mammoth in Europe, having been dredged in the Bay of Galway. Its history has been verified to me by the Earl of Enniskillen, who came into the possession of the specimen soon after the discovery, and subsequently presented it to the National Collection. The surface is dark-coloured, as if derived from mud, and covered with shells of *Balanus* and *Polyzoans*. There is a loss of portion of the great tuberosity

[1] But there are exceptions in individual humeri of the Mammoth both as to the length and inclinations of the supinator ridge. These are well seen in No. 26,259, B. M., Owles' Collection from the Dogger Bank, where there is a very short supinator ridge, the upper border of which is nearly at right angles to the shaft, whilst another, No. 46,258, in the same collection, and also from the Dogger Bank, has the supinator ridge much inclined.

and a small piece of the supinator ridge, otherwise it is quite entire. The dimensions are given in the table, page 215. It is seven inches longer than the smallest adult humerus from Ilford in the British Museum, and is six inches shorter than that of the Lena skeleton in St. Petersburgh, which is forty inches long. The nutrient foramen in the former is situated about 15·5 inches from the head.

A summary of the characters appertaining to the humerus of the Mammoth and Asiatic Elephant, in contradistinction to the same bone in the African species, and supported by numerous examples, refers to—

1. Greater depth and narrowness of the bicipital groove.
2. Greater compression of the head and tuberosity,
3. Less saliency of the supinator ridge.
4. Prominence of the deltoid ridge.
5. Greater hollowing out of the shaft at the insertion of the supinator ridge.
6. Narrow and deep trochlea.
7. More defined margins of the cubital articular surfaces.

A few comparisons between the humerus of *E. primigenius* and that of *E. antiquus* and *E. meridionalis* are referred to at p. 57, and will be further noticed in the sequel, page 216, in connection with the latter species.

7. CUBITUS.

Ulna.

1. Cuvier states that the radius crosses the ulna in a more oblique direction in the Asistic than in the African; and this appears to be the case as regards the forearm of 708 H, B. M., African, as compared with several specimens of that of the Asiatic.

In the Mammoth the bone commences to cross lower down than in either of the above, about the junction of the middle with the lower third, as shown in Plate XVIII, fig. 1.

2. Busk has pointed out[1] that the radial sulcus of the *ulna* is more rounded and shallower in *E. Africanus* than in *E. Asiaticus*.

Several ulnæ of the Mammoth seem to agree with *E. Asiaticus*, as shown in fig. 1 *a*. It will be noticed, however, presently, that there are exceptions to this condition among Arctic specimens in the British Museum.

3. Busk further observes that the inner articular facet is wider at what may be termed the neck in the *E. Africanus* than in *E. Asiaticus*. Here, again, in the Mammoth, as seen in fig. 1 *a*, it presents the character of the latter.

4. The anterior and lower third of the shaft is more flat in the African (708 H) than I have seen it in the Mammoth and Asiatic, which are much alike.

[1] Op. cit., p. 247.

5. The posterior or olecranon ridge is more rounded and blunt in the African ulna than in any of the Mammoth and Asiatic I have examined; it is also more arcuated in the former.

6. The external border of the shaft is more rounded in the African specimen than obtains in many ulnæ of the Asiatic, whereas in the Mammoth it is scarcely so sharp as in the latter.

7. The distal articular surface varies so much in the convexity and configuration of the cuneiform aspect in the Mammoth and Asiatic as to appear to me of little value as a means of diagnosis.

The above seem to me the only differences in any way persistent, at all events as far as many *ulnæ* of the Mammoth and Asiatic are concerned. Of course, the data obtained from a single instance of the African Elephant cannot be considered very reliable.

The two elements of the forearm of the Mammoth are well seen in specimens from the Arctic regions in the British Museum. Three ulnæ from Eschscholtz Bay present only one character in any ways different from similar bones from Ilford and other British localities. The exceptional condition is in the radial notch, which is wide, like that of the African, in two; whilst the third is like that of the Asiatic and all other ulnæ of the Mammoth I have examined.

The Brady Collection, B. M., contains fourteen specimens either entire or fragmentary. The right cubitus from Ilford (Pl. XVIII, figs 1 and 2), although somewhat longer than any of the above, preserves the same characters. Of these forearm bones the ulna (No. 38,101) is 28 inches in length and its radius (38,012) 24½ inches. The width of the proximal articulation is 7½, the cuneiform facet being 2¾ inches in the antero-posterior by 3½ inches in the transverse diameter.[1]

The smallest entire ulna, $\frac{C}{146}$, Brady Collection, is 26 inches in length, being quite in proportion to the small humerus, $\frac{C}{128}$. Thus, the arm and forearm of an individual of these dimensions would be about 4 feet 6 inches, and supposing the above and other bones proportionate to those of a recent Elephant they would give a height of about 8 feet at the shoulder, or the ordinary height of an adult of the Central-Indian variety, which, on the whole, furnishes a fair estimate of the size of the Mammoth which frequented South-eastern England and the banks of the Thames during the period of the deposition of the brick-earths of Ilford.

Besides the instance recorded at p. 60, of anchylosis of the radius to the ulna, there is another highly characteristic example of the cubitus of a young Mammoth from Ilford in the National Collection, showing a complete bony union of the two elements.

[1] I may here observe that the articulating surfaces of the long bones were measured by tape along their surfaces; the same with the acetabulum and glenoid cavity of the scapula, &c.

As compared with *E. antiquus;* the radial sulcus is deep and narrow in the latter, whilst it is wide and shallow in *E. meridionalis.*

The head of the olecranon seems to tend more inwards in *E. antiquus* than in the Mammoth, and apparently in *E. meridionalis.*

Radius.

Like the fibula, the radius is subject to certain individual differences in the prominence or otherwise of ridges and the degree of flattening, breadth, or rounding of its surfaces. But there are a few characters apparently characteristic of species.

1. The anterior aspect is in general much more rounded in the Asiatic and Mammoth (Plate XVIII, fig. 1) than in the African. In the radii referred to the *E. antiquus* [1] it is apparently broader, and more flattened than in the two former. In the enormous radius of *E. meridionalis,* in the collection of R. Johnson, Esq., from Palling, on the Norwich coast, this aspect is not so pronounced as in the Asiatic; but the narrowness so prominent, amounting to a shin, in the anterior upper third of the African is not observed in any of the British fossil radii nor in *E. Asiaticus.*

2. The upper and outer side of the shaft is more flattened in *E. antiquus, E. Africanus,* and in *E. meridionalis,* than in *E. Asiaticus* and *E. primigenius.*

3. The inner aspect of the shaft in the above presents these characters. It is round in *E. primigenius,* flattened in *E. Africanus, E. antiquus,* and *E. meridionalis,* whereas it is narrow and sharp in *E. Asiaticus.*

4. A prominent ridge rises close to the inner aspect of the head in the African, and runs obliquely downwards towards the external malleolus, where it joins the anterior ridge or shin.

In the Asiatic and Mammoth this character is not nearly so pronounced, nor is it the case in *E. antiquus* and *E. meridionalis.*

Neither the proximal nor the distal articulations present seemingly distinctive characters of a reliable nature.

5. The radius generally is relatively stouter in the Mammoth and *E. antiquus* than in the two recent Elephants; on the other hand, considering the much greater dimensions of that of *E. meridionalis,* it has a more slender aspect than in the two former.

Owing to the slender form of this bone it is rarely found entire in the fossil state. The Brady Collection contains several specimens, a few of which are nearly entire, but none so perfect as that belonging to the ulna (Plate XVIII, figs. 1, 2) already noticed.

[1] Page 59.

8. MANUS.

The elements of the fore foot of the recent species present a few apparently distinctive characters, but collectively there does not appear much difference in relative size.

Carpus.

Scaphoid.—In my monograph on the 'Maltese Fossil Elephants'[1] I have referred to differences in the configuration and articular surfaces of this bone in the two recent species and the Mammoth, which a more extended field of observation does not seem to controvert. These are, briefly—(*a*) The posterior border is more rounded in the African and Mammoth than in the Asiatic, in which it is more constricted about the middle. (*b*) The radial facet is generally (I have met with one or two exceptions, however) more erect in the Asiatic and Mammoth than in the African. (*c*) The trapezoidal and magnal articular aspects form a triangle in the African, and are slightly concave, whereas in the Asiatic and Mammoth the hollowing out is confined to the magnal surface, and the entire articular aspect is quadrilateral and slightly convex about the middle, and is oval at the summit, where it is rather concave. This surface is more continuous in the African; the facets for the magnum and trapezoid not being so defined as in the Asiatic and Mammoth.

I have not seen a scaphoid referable to *E. antiquus*, but a colossal specimen of that of *E. meridionalis*, No. 150, of the Gunn Collection, Norwich, from the Forest Bed Series, shows a narrow constriction at the middle, as in the Asiatic and Mammoth. The trapezoidal and magnal facets are, however, like the African, the surface for the former being nearly flat and the radial aspect nearly horizontal.

This bone varies in length, being usually between $5\frac{1}{2}$ to $4\frac{1}{2}$ inches in the Mammoth, whereas the colossal bones from the Norfolk coast often exceed that by two inches.

Lunare.—The ulnar facet is more erect in the Asiatic and Mammoth than in the African specimen, 708 H, B. M. In the large lunare, No. 155, Gunn Collection, Norwich, it is intermediate, being not so perpendicular as in the former.

The magnal surface is hollowed out to a greater extent in the Mammoth and Asiatic than in the African, but it is still more so in No. 155 just referred to, in which the anterior aspect is quite flat. The latter, moreover, has no scaphoidal facets, which are, however, sometimes very small, and even wanting in large individuals of the other forms, indeed, in another specimen, No. 151 of the Norwich Collection, from the same locality and of the same size as No. 155, both the scaphoidal facets and the flattening are absent.

The dimensions of the lunare of *E. primigenius* seems seldom to exceed a maximum

[1] 'Trans. Zool. Soc. London,' vol. vi, p. 66.

length of 5 inches, whereas the above specimens referred to *E. meridionalis* from the pre-glacial deposits of Norfolk are as much as 10 inches in length.

Cuneiforme.—The ulnar surface of this bone is concave in the Mammoth and Asiatic about the middle, and the same obtains likewise in several colossal specimens referable to *E. meridionalis*, or else large individuals of *E. antiquus* in the Gunn Collection. This central depression is absent in the cuneiforme of 708 II, African, in the British Museum, in which there is a depression at the anterior apex not observable in any of the above.

The bone is relatively thicker at the external margin of the pisiform facet in the Asiatic and Mammoth generally than in the African specimen, and the same is apparent in the enormous bones from the Norfolk coast; the character, however, is not invariably pronounced. The length of the cuneiforme in the Mammoth seldom exceeds 5½ inches, whilst, as will appear in the sequel, the same bone in *E. meridionalis* and in *E. antiquus* attained far greater proportions.

The *pisiforme* is not preserved in any collection of the British fossil Elephants examined by me.

Trapezium.—This element of the carpus, like the trapezoid, if the specimens figured on Pls. XIX and XXI are typical of the species, would seem to present some valuable diagnostic characters. The following are in the British Museum:

1. The specimen (Pl. XIX, fig. 8), No. 36,611, left foot, referred to *E. primigenius*, is from Maidstone, Kent. The length is 2·5, and maximum breadth 2·8 inches, girth 7 inches. In the Asiatic the first two proportions stand as 2·3 to 3 inches. The bone is relatively longer, but the contour is not very different; the same may be said of the African Elephant.

2. No. 20,821 (fig. 9) is a right trapezium of *E. antiquus* from Grays, Essex, where remains of this species are plentiful. It is 4 inches in length, with a maximum breadth of 4 inches and girth of 10·4 inches,

3. No. 33,418 (fig. 10), a right trapezium of either *E. meridionalis* or *E. antiquus*, is in the Layton Collection from the East Coast. The bone is dark-coloured, and may, on that account, have been derived from the Forest-Bed Series. The length is 3·5 inches breadth 3·8 inches, girth 9·4 inches. The specimen is decidedly small for *E. meridionalis*; but unless the bone is subject to much variability in the configuration as well as dimensions, it seems quite distinct from the other two, which also present individual peculiarities. These discrepancies are well shown in the figures, and refer to the following points:

1. General outline. The contour of the inner border of the bone from Maidstone (fig. 8) rises from the metacarpal surface at an angle of about 45°, and declines suddenly at the summit, whilst its outer border is slightly concave, and its breadth exceeds the length.

The outline of the Grays specimen (fig. 9) shows a remarkable concavity of the

inner border, and a more horizontal upper surface, whilst its length and breadth are nearly equal. The outer border is somewhat convex.

The inner border of the East-Coast specimen (fig. 10) is inclined below, suddenly becoming erect, and gradually declines towards the summit; the outer border is very uneven. It is broader than it is long.

2. The scaphoidal and trapezoidal facets of fig. 8 *a*, as regards outlines and surfaces, are widely different from figs. 9 *a* and 10.

3. The metacarpal aspects are also perfectly distinct in figs. 8 *b*, 9 *b*, and 10 *b*.

How far a series of specimens would show these to be only individual and variable characters I cannot say, at all events the above appears to me worthy of illustration.

Trapezoid.—The two bones just described from Grays and Maidstone, referable to *E. antiquus* and to *E. primigenius*, present, in their *trapezoids*, discrepancies equally noteworthy. Possibly the two elements of the foot belonged to the same individual, seeing that the trapezoids are from the same localities.

The trapezoid of the Mammoth (Pl. XXI, fig. 3), 23,119, B. M., from Maidstone, is of the left side, and fits fig. 8, Pl. XIX. It is 4·5 inches by 2·5 inches, with a girth of 8·5 inches. It is remarkably narrow as compared with the Grays specimen of *E. antiquus* (Pl. XXI, fig. 4), which represents a left trapezoid, No. 36,609, B. M.; it is 3·5 by 2·8 inches, the girth is 8·4 inches.

The general contours of these two bones, and of their carpal and metacarpal facets, supposing fig. 3 is that of *E. primigenius* and fig. 4 belongs to *E. antiquus*, are certainly very remarkable. These are, however, the only instances known to me of this bone, excepting a much larger example of *E. meridionalis* from the Norfolk coast. The latter partakes more of the characters of *E. antiquus* than of the Mammoth. Here, again, it is desirable to examine several specimens before a definite conclusion can be come to.

In the Asiatic Elephant the bone, as regards relative dimensions and contour, is certainly more closely allied to fig. 4 than fig. 3.

Magnum.—The characters of this bone are much alike in the recent and fossil Elephants. The lunare aspect is generally more concave in the Mammoth and Asiatic than in the African, and this is more or less apparent also in the specimen I have referred to *E. antiquus*.[1] Large magna from the Forest Bed will be referred to in the sequel. Very often the trapezoidal facet is divided in the Asiatic and Mammoth, but it is not so in 708 H, African. This bone seldom exceeds 5 inches in its greatest length in the Mammoth, the generality of specimens being little over $4\frac{1}{2}$ inches, whereas individuals of *E. antiquus* and *E. meridionalis* show a maximum length of 7 inches.

Unciforme.—The facet for the third metacarpal, said to be absent in the Asiatic,[2] is certainly not an invariable condition; indeed, from what I have seen, it is usually present. It was present in the magna of *E. antiquus* and *E. meridionalis*, as recorded at p. 60.

[1] Page 60.

[2] De Blainville, vol. iii, p. 42.

The maximum length in the Mammoth seldom exceeds $5\frac{1}{2}$ inches, whereas in *E. antiquus*[1] it is 6·8 inches; and several still larger specimens are represented in the British Museum, Gunn Collection, and that of A. Savin, Esq., of Cromer, all of which may probably belong to *E. meridionalis* or *E. antiquus*.

Metacarpals.

First digit.—The first metacarpal of the Mammoth does not seem to present any character different from that of the Asiatic, which, however, as far as the afore-noticed single instance of the African is concerned, may be distinguished by the upper and lower surfaces of the shaft in the two former being not so broad and flattened as in the latter. This bone and its homologue of the hind foot are seemingly shorter in the African than in the Mammoth and Asiatic Elephant, and there is apparently a few differences in the contours of the distal articulating surface in the Mammoth and Asiatic as compared with the African species and *E. meridionalis*, which are more alike.

A colossal bone of this member of the manus, $4\frac{1}{2}$ inches in length, found on the beach at *Cromer*, is in the Gunn Collection. This specimen in the concave upper aspect of the distal facet presents a character of the African, but otherwise the general outline and circular contour of the proximal articular surface show no very close affinities with either of the recent Elephants.

Second digit.—Comparisons of these elements of the fore foot of the Mammoth with similar bones of the recent species do not point to any characters available for diagnostic purposes.

The second metacarpal of the Mammoth is represented in the Owles Collection and the Brady and Gunn Collections, the largest being 5·8 inches.

There is a large specimen in the Owles Collection, B. M., from the Dogger Bank, 7·5 inches in length. The proximal articular surface is $5{\cdot}8 \times 3$ inches, and the distal 4·4 inches in height by 4·4 in width. The girth midshaft is 8·8 inches.

This digit is not relatively stouter nor longer than in the recent Elephants, and the same character may be said generally to obtain, at all events with the three longest toes, in the fore and hind feet of the Mammoth.

The first phalanx is more even at its proximal or metacarpal articular aspect in both the Asiatic and Mammoth than in the African, in which the foot is relatively broader, but these characters may not be persistent.

Third digit.—The sides of the metacarpal are more flattened in the African than in the Mammoth and Asiatic.

The magnal surface is more concave in the two last-named species, which differ from *E. antiquus* as regards the contours of the central and marginal facets, as seen in Plate XVIII, fig. 7, of the Mammoth, and fig. 6 of *E. antiquus*, on the one hand, whilst

[1] Page 60.

that of *E. meridionalis* (fig. 5) is narrower than either. How far these characters admit of constancy in the three species can only be determined by comparisons of numerous examples. I must state, however, that several specimens referable to *E. meridionalis* maintain the aspect of the proximal extremity shown in fig. 5.

The average length of the third metacarpal in the Mammoth seldom exceeds $8\frac{1}{2}$ inches.

Fourth digit.—There are apparently no characters of a reliable nature in the fourth metacarpal in connection with recent and extinct species to require particular notice. The bone averages from 7 to 8 inches in length in the Mammoth, whereas specimens referable to *E. meridionalis* or *E. antiquus*, from the Norfolk submerged deposits, attain to almost 9 inches, and fragments indicate even longer bones.

Fifth digit.—The fifth metacarpal is not so broad in the Mammoth and Asiatic as in the African Elephant, and the unciform facet is circular in outline in the two former generally, although specimens show an approach to that of the African, which is oval.

The proximal phalanx appears generally more compressed at midshaft in the Asiatic and Mammoth than in Specimen 708H (African) in the British Museum. There are other small points with reference to the distal articular surfaces possibly distinctive of the bone in the recent Elephant of Asia as compared with the African, but these are irregular in the Mammoth.

There is seemingly a wide difference in all these characters in the equivalent bone of *E. meridionalis* (Plate XVIII, figs. 8 and 8 *a*), more especially in the contour of the proximal articular surface, as will be indicated in the sequel.

Phalanges.

The phalanges of the first, second, and fifth digits show apparently several differences in the recent species, more especially the proximal and distal elements, as recorded elsewhere,[1] and as far as I have been enabled to compare them with similar bones of the Mammoth they show closer affinities with the Asiatic than with the African Elephant.

9. FEMUR.

The comparisons of Cuvier and De Blainville in relation to the humerus have the same force with reference to the femora of the two living species. As regards the Mammoth, out of numerous instances from the Arctic region and British strata, it appears to me that the thigh, like the arm, was relatively shorter than in the recent Elephants. But at the same time there is marked variability in individuals of many species of Proboscidea.

1. Comparing the length and direction of the neck in many instances of the

[1] Adams, 'Trans. Zool. Soc. London,' vol. ix, p. 90.

Mammoth's femur with the same parts in the Asiatic, and with a single example of the African, I find that it is decidedly longer in the Asiatic than in the African, 708H, B. M., and is shorter in the Mammoth than in either; this obtains likewise in a superb specimen from MUNDESLEY, Norfolk coast, which might be fairly referred to *E. meridionalis*. This enormous bone, perfectly entire, is no less than 5 feet in length. It was discovered within a few feet of a radius (3 feet 3 inches in length) and the enormous humerus, No. 200 of the Gunn Collection, Pl. XVI, fig. 2, so as to render it probable that the three bones belonged to the same individual.

2. A rudimentary trochanter minor is often traceable in the Asiatic and Mammoth, and is present in the above-named femur of *E. meridionalis*. This tuberosity is absent in femur 708H of the African. The amount of obliquity of the head is not constant, some specimens being much more inclined than others.

3. The relation of the great trochanter to the head is seemingly subject to variability, but in nearly all perfectly entire specimens of the Mammoth it is almost level with the epiphysial junction of the latter (Pl. XIX, fig. 7), whereas it is considerably below it in the Asiatic. In this respect the MUNDESLEY specimen resembles the Mammoth. Unfortunately the part is not present in 708H, B. M., African; however, according to Cuvier, the summit of the great trochanter is above the level of the apophysial union.[1]

4. The digital pit has a broader outer wall in the Mammoth and colossal Norfolk femurs than in either of the recent species.

5. The position of the nutrient foramen may be considered variable as to position, but it is usually higher up in the Mammoth and Asiatic than in the African. It is undeterminable in the huge thigh-bones from the Norfolk coast, the opening having become filled with matrix.

Surfaces of the Shaft.

Some stress has been put upon the four surfaces of the shaft as distinctive of species, and, although always well marked, there is seemingly individual variability, not only in respect to their evenness, but also the degrees of sharpness or rotundity of their margins. Much, no doubt, depends on the size of individuals and the habits of the species. The colossal Forest-Bed Elephants were evidently less given to active muscular exertions as compared with the feral individuals of recent species and the Mammoth, if we may judge from the absence of pronounced articular surfaces and ridges for muscular attachments.

I have compared many femora of Mammoths with the same bones of recent species and a few examples of the colossal femora from East Anglia, with the following results as regards their shaft. I have not seen an entire femur referable to *E. antiquus*.

1. *The anterior surface* in the Mammoth is broad and flat in many (fig. 7), whilst in other adult specimens it is narrow and round. It is remarkably broad in three

[1] 'Oss. Fossil.,' pl. ii, fig. 6.

enormous bones in the collections of Mr. Gunn, Mr. Johnson, and Mr. Backhouse, from the Forest Bed; but altogether it is slender as compared with them.

2. *The posterior surface* is considerably less flattened in the Mammoth and these huge bones and in the Asiatic than in the African, the external border being more pronounced in the Asiatic than in the other two, whilst it is rounded in the African.

3. *The external surface.*—It is nearly even throughout in the African (708h), whereas it bulges at the third trochanter in the Mammoth and Asiatic. In some femora of the former, such as $\frac{C}{190}$ (fig. 7) and $\frac{C}{197}$ of the Brady Collection, B. M., from Ilford, this character is pronounced to a greater extent, whereas another femur, $\frac{C}{193}$ in the same collection, the bulging is not so well marked. In the other fossil femora neither character is very evident.

4. *The internal surface.*—It is broader and more even in the Mammoth than in either of the recent species, and more so in the African than in the Asiatic.

Condyles.

The relative dimensions of the condyles do not seem to furnish important distinctions. I have noticed the differences in the width of the inter-condyloid spaces in the recent species,[1] or rather the degrees of convergence, which is greater in the Asiatic than in the African, 708h B. M., and this seems to be the case very generally in the Mammoth (Plate XIX, fig. 7*a*, and Plate XXII, fig. 6), and the same is shown in the condyles of the femur in Mr. Johnson's possession described in the sequel. Individual differences occur in other specimens of large thigh-bones from the Norwich coast, as seen in Gunn's Collection, and, as before noticed,[2] the condyles referred to *E. antiquus*, from Walton, are not quite so convergent as in the Mammoth.

The patellar surface is broad and shallow in 708h (African), whereas in the Mammoth, and in the huge femora of *E. meridionalis*, it is generally more concave and deeper (see Plate XIX, fig. 7, Plate XXII, figs. 5 and 6, and Plate XXVI, fig. 3*b*).

In Beechy's 'Voyage of the Blossom'[3] there is represented a femur of the Mammoth from Arctic America. The specimen is in the National Collection. It is remarkable for its long and slender shaft. The following are its dimensions:

Length 39 inches; to the neck 36 inches.

Girth at midshaft 12 inches.

The smallest width at midshaft $4\frac{1}{2}$ inches.

[1] P. 62. I must here correct a slip of my pen in connection with the degree of convergence of the condyles of the femur in *E. Asiaticus*, where I state that "in the Mammoth and *E. Asiaticus* the condyles are 'more apart,'" which should be *more convergent*.

[2] P. 62.

[3] Plate ii.

Breadth above the condyles $6\frac{3}{4}$ inches.

Antero-posterior diameter at the distal end 4·4 inches.

Antero-posterior outer condyles $6\frac{1}{2}$ inches.

Antero-posterior inner condyle 8 inches.

Greatest width between inner borders of the condyles 3 inches.

The nutrient foramen is within 15 inches of the head on the inner and posterior surface.

Another left femur, in the same Collection, is 48 inches in length, with the nutrient foramen at the same distance from the head. Various examples are given by authors. Thus, Breyne[1] refers to a femur from Siberia 36 inches in length and 13 inches in girth at midshaft. Cuvier represents a Siberian specimen no less than 42 inches in length without the proximal end, and De Blainville also refers to similar specimens.

With reference to femora from British strata. The Owles Collection from the Dogger Bank contains several thigh-bones of the Mammoth, several of which indicate very large individuals. Thus, No. 46,275 shows an antero-posterior diameter of the inner condyle (by tape) of $11\frac{1}{2}$ inches, and the outer $9\frac{1}{2}$ inches; the breadth across the condyles is 9·2 inches.

The right femur, No. $\frac{C}{190}$ of the Brady Collection, B. M., from Ilford (Plate XIX, fig. 7), is an excellent example of the thigh-bone of the small variety of the Mammoth from the above locality. Its dimensions are given in Davies's Catalogue. The length, however, is less than there stated, being 40 instead of 45·5 inches; its girth midshaft is $14\frac{1}{2}$ inches. The antero-posterior diameter of the inner condyle is 8·3 by callipers, and $15\frac{1}{2}$ inches by tape; the outer is 7·6 by callipers, and $13\frac{1}{2}$ inches by tape.

There is also another very perfect specimen from the same locality in the possession of Professor Tennant, F.G.S., the length of which is $37\frac{1}{2}$ inches, and least girth $12\frac{3}{4}$ inches.

A huge left femur in the British Museum, dredged on the Dutch coast, has lost the head and great trochanter, leaving a length of 46 inches; the girth midshaft is $15\frac{1}{2}$ inches. The nutrient foramen is about the junction of the upper with the middle third. Another femur from the same locality, with the head and neck wanting, gives a length of 45 inches. The molars of the Mammoth dredged on the coast of the Netherlands and eastward perfectly correspond with these large bones.[2]

[1] 'Phil. Trans.,' vol. xl, p. 124.

[2] I have just lately been shown at Lowestoft, Suffolk, a superb left lower ultimate molar of the Mammoth dredged off Spimlico on the German coast. It is one of the most entire of any molar of this Elephant that has come under my notice. The enamel is very thin, as in the Dogger Bank and Arctic molars. It is 12 inches in length by $3\frac{1}{2}$ in maximum breadth, and holds a formula of x 21 x. The anterior fang is curved backwards, followed by 6 or 7 fangs, and terminating in a hollow shell. Several teeth in the possession of J. J. Colman, Esq., M.P., of Corton, Suffolk, were dredged off Lowestoft, of a precisely similar character. One enormous thin-plated tooth, No. 35 of Mr. Randall Johnson's Collection, was also dredged thirty-five miles to the south-east of Lowestoft. It is in such a state of integrity that it

An abnormal femur, No. 255 of the Gunn Collection, with the ends completely consolidated, is 39 inches in length. The neck, instead of being much inclined, is nearly erect, with the head fully $5\frac{1}{2}$ inches above the level of the great trochanter, thus furnishing a marked exception to the generality of specimens. The girth midshaft is $11\frac{1}{4}$ inches. This bone was dredged off Yarmouth. With the above exception it agrees in all the foregoing characters. Another femur from the East coast is 41 inches in length, with a girth of midshaft 13·8 inches. The characters agree with typical femora of the Mammoth.

The patella is not common; there are two specimens in Dr. F. Spurrell's Collection from Crayford. One indicates a small individual, as is also represented by several teeth and bones of the Mammoth from the same situation. Neither of the former differ from patellæ of recent Elephants; and they partake of like irregularities in shape. The smaller specimen is 3·5 × 3·4 inches in breadth, and has a girth of 9·4 inches, whilst another is 4 × 4·5, and is 11·5 inches in circumference.

The above instances of the femur in adult individuals sufficiently attest the varieties in size to which the Mammoth was subject—a mutability common also to recent species, and considering the world-wide distribution of the former, it need not be a matter for wonder that it was subject to considerable variability; still, considering the varieties of climate and physical conditions, there is a remarkable persistence of character throughout, as compared with allied forms, showing thereby that the main characters were preserved throughout the Post-Glacial period, whatever may have been the ancestral connections of the Mammoth.

10. TIBIA.

There appears to be in this bone little of importance of a very stable character distinctive of species. The shin is prominent, with a deep cavity for the tibialis, in the generality of leg-bones of the Mammoth (Pl. XIX, fig. 12), and also in the Asiatic. This point is scarcely so pronounced in the African Elephant. Like the other bones of the extremities, the tibia is shorter in the Mammoth than in the two last named.

The facet at the distal end for the fibula is decidedly more oblique in the Ilford Mammoth (Pl. XIX, fig. 12 *b*) and in the Asiatic Elephant than in the African; it is less apparent in the huge bones from the East coast, and in several relatively larger and stouter tibiæ from the fluviatile deposits of the Thames Valley referable to *E. antiquus*, Pl. XIX, fig. 11 *b*.

The contours of the proximal articular surfaces of *E. primigenius* and *E. antiquus*, as shown in figs. 12 *a* and 11 *a*, present also differences; the latter being not so circular,

might have tumbled out of the alveolus into the fisherman's trawl. The specimen is an ultimate molar of the upper jaw, left side, and holds *x* 24 *x* in 14 × $3\frac{1}{2}$. The highest colline is $8\frac{1}{2}$ inches.

whilst the distal tarsal surface of *E. antiquus* (Pl. XIX, fig. 11 *b*) is more rounded, and not so defined as in *E. primigenius* (fig. 12 *b*).

There are in London Collections several good examples of this bone from the Thames Valley deposits.

In the Cotton Collection, Museum of Practical Geology, there is a tibia, No. 2, from Ilford, the dimensions of which are as follows:—Length is 23·5, girth, midshaft, 10·5 inches; girth of the proximal extremity 22·8, and distal 17·5 inches. Breadth of proximal articular surface 7·4 inches, the distal being 4·5 by 3·8 inches.

The above is matched by several specimens from the Dogger Bank and elsewhere. Two tibiæ in the Beechy Collection from Arctic America are 23 and 20 inches in length respectively.

The bone varies apparently in the adult from about 20 to 25 inches in length.

The above-mentioned tibia from Ilford, $\frac{C}{213}$, Brady Collection (Pl. XIX, fig. 12), has all the characters of the Arctic specimen, and represents the small-sized animal from that locality. The dimensions are—Length 20 inches, width, proximal end, 7 inches, width, distal end, 5·8 inches.[1]

The measurements of an entire tibia belonging to an adult individual, in connection with other portions of a skeleton of a Mammoth, from Shandon Cavern, Waterford, are recorded in my report on that rock cavity.[2] These are as follows:—The length is 22 inches; girth, midshaft, 10·8 inches; the proximal articulation 8×6, the outer condyloid cup being $3·5 \times 3·5$, and the inner $4·4 \times 3·7$ inches. The distal articulation was 3·8 in the a. p. d. by 4 inches.

The tibiæ from the East coast deposits, as far as I have seen, are of two sorts. A remarkably slender tibia is dredged up occasionally by trawlers, or met with on the strand, and also in Post-Glacial deposits. This bone, by comparison with the Arctic remains of the Mammoth, is clearly inseparable; but occasionally along with the above, in Post-Glacial deposits, or in solitary instances, a much stouter and longer tibia is met with. Whether only a monster individual of the Mammoth, or that of either of the two other species, is not clear. Again, in the Forest Bed we find tibiæ not usually much longer than the equivalent bone of the Mammoth, but relatively much broader, and quite in keeping with the other huge bones of *E. meridionalis*.

There is a tibia, discovered at Harswell, in Yorkshire, now in the Leeds Museum. It is 24 inches in length, the breadth at the proximal end is 7·5 by 5 inches, and that of the distal 4·5 by $3\frac{3}{4}$ inches, whilst the girth, midshaft, is 13 inches. There is a possibility, however, that it may belong to *E. antiquus*, which was the Elephant of the Kirkdale and other Yorkshire Caverns.

Another unusually stout and large tibia in the Cotton Collection, Jermyn Street

[1] Davies, 'Cat. Brady Collection,' p. 24.

[2] 'Trans. Roy. Irish Acad.,' vol. xxvi, p. 214.

Museum, from Ilford, I am likewise disposed to place with *E. antiquus* for the same reasons. The following are its dimensions:—Length 26·8 inches; girth, midshaft, 13 inches, girth, proximal end, 27·5, and of the distal 22 inches; breadth, proximal articular surface, 8·5 inches, ditto, distal, 5·4 by 4·3 inches. The distal fibular facet is oblique, as in the Mammoth. The remarkable grossness of both these bones is in so much keeping with numerous instances of Mammoths' tibiæ from the Arctic regions and British strata, that I am inclined to place them with the large bone described from Camberwell, Surrey.[1] This tibia is shown in Pl. XIX, fig. 11, for the purpose of comparison with that of the Mammoth (fig. 12).

Another large and very stout tibia, No. 48,134, B. M., Ilford, shows a prominent incurving shin, with a deep pit for the extensor muscles. The length is 25 inches, the girth, midshaft, is 12·4 inches, and the inferior articular surface 4 (a. p. d.) $\times 5\frac{1}{2}$ inches. Whether such leg-bones belonged to unusually large individuals of the Mammoth, or its more ponderous ally, the *E. antiquus*, it is difficult to say. The tibia, like the femur, was no doubt subject to considerable individual differences in size.

11. FIBULA.

A noticeable external character in the fibula of the Mammoth is that in several specimens the outer surface of the shaft is decidedly broader in it, the Asiatic, and the huge bones from the East coast, than appears in the single specimen of the African in the National Collection; moreover, as a general rule, the distal tibial facet is more horizontal in the latter than in them. This is seen in Plate XIX, fig. 4, No. $\frac{C}{220}$, Brady Collection from Ilford, as compared with the huge bone from Cromer (fig. 3). These two bones will be seen to differ also in the contours of their tarsal articular surfaces.

In a large collection of Mammalian remains from the Crayford brick-earths, Kent, belonging to Dr. Flaxman Spurrell, of Belvedere, there is an entire fibula of the Mammoth. The upper facet is oblique, and so is also the distal tibial articular surface. The bone is compressed from side to side at its proximal end, and a prominent external ridge runs down the shaft. There is also an internal ridge, which is sharp, and descends from the head to the internal angle. The bone is almost triquetrous.

The length is 19 inches, and maximum breadth of the distal extremity 3 inches.

12. PES.

The hind foot, like the manus, appears to have been relatively smaller in the Mammoth than in either *E. antiquus* or *E. meridionalis*.

[1] Page 63.

Tarsus.

Astragalus.—1. The posterior border is more even, and the posterior internal angle less pronounced in the African and the gigantic bones from East Anglia (Pl. XIX, fig. 6) than in the Mammoth (fig. 5) and Asiatic Elephant, which are similar in these respects.

2. The tibial aspect is usually more concave from side to side in the Mammoth and Asiatic than in the African and the enormous bones from the Forest Bed.

3. The navicular facet is seemingly not so convex in the Mammoth (fig. 5) and *E. meridionalis* (fig. 6) as in the Asiatic, in which it is more prominent than in the African; the same appertains to the peroneal facet.

4. The calcaneal facets present striking characters; the dividing pit is much broader in the Mammoth (fig. 5) and Asiatic than in the African and the large bones from the Forest Bed (fig. 6), where the articular surfaces are always completely isolated by a deep valley running tortuously across the surface.

5. In *E. meridionalis* (fig. 6) the articular surfaces are more even than in the Mammoth and the two recent species, the inner being crescentic and the outer quadrilateral, as seen in fig. 5, whilst in *E. meridionalis* (fig. 6) the former is triangular and the latter has the inner border more tortuous.

The early ossification of the bones makes it difficult to pronounce on the age of an individual. But generally a large astragal of the Mammoth may be about 5·5 inches in the antero-posterior and lateral directions. The small specimen from Ilford (fig. 5) has a tibial facet of only 4·5 × 4·5 inches.

Another astragal from the Shandon Cave, Waterford, belonging probably to the individual which owned the axis, dorsal vertebræ, and other bones already noticed, is preserved in the Museum of Science and Art, Dublin. It is 3·8 in the a. p. d. diameter by 5·3 in width, the navicular facet is 4·6 in width by 2·5 in height, whilst the calcaneal (outer) is 3·2 × 2·3, and the inner 3·3 × 1·8 inches. These measurements, however, refer to what must have been a rather small individual, as proven, also, by the teeth and bones.

Calcaneum.—The observations on this element of the hind foot of *E. antiquus* at page 64 appears to hold good after a more extended examination of specimens. The only point I observe deserving of further notice is that the upper surface of the heel, generally narrow in *E. Asiaticus* and *E. primigenius* (Plate XIX, fig. 1), and round in 708h, *E. Africanus*, appears to be occasionally also round in *E. antiquus*, as seen in fig. 2. It is invariably broad in *E. meridionalis*. The dorsal surface of the heel may therefore be subject to individual variability, and can scarcely be accepted as diagnostic of species. The *E. Africanus* shows a relatively larger cuboidal facet, and a more oblique peroneal, and more even astragal facets than *E. primigenius* and *E. Asiaticus*. The points of distinction between the calcaneum of *E. primigenius* and *E. meridionalis* will be noticed in the sequel.

The following may be considered as average dimensions of this bone in the Mammoth. In the British Museum the calcaneum figured in Beechey's 'Voyage of the Blossom,'[1] from the Arctic Regions, is $6\frac{3}{4}$ inches in length by 5 in its maximum breadth. Another large specimen from the same region has a maximum length of 10, and a maximum breadth of $7\frac{1}{2}$, inches. The last displays a broad upper surface, and is therefore exceptional as compared with the generality of Mammoths' calcanea. The calcaneum of *E. antiquus*, No. 27,940, B. M. (Pl. XIX, fig. 2), from Grays, Essex, is $7\frac{1}{2}$ by 5 inches in breadth; its facets for the astragal will be seen to differ in their contours as compared with the Mammoth (fig. 1), the outer being nearly four-sided, whilst it is ovoid in *E. antiquus*, and the inner, which is triangular and deeply notched externally in the former, is crescentic in the latter. The interosseous pit is less open anteriorly and posteriorly in the Mammoth (fig. 1) than in *E. antiquus* (fig. 2). The heel is also more prominent in the Mammoth.

Naviculare presents no important diagnostic characters as regards species.

The dimensions of No. 27,931, B. M., from Walton, in Essex, are 6 in breadth by $3\frac{1}{4}$ inches in height, and most probably represent that of the Mammoth.

Cuboid.—A comparison of several cuboids of the Mammoth with those of the two recent species seems to show that, whilst the external and internal sides are subequal in length in the African, they are about equal in the Mammoth and Asiatic.

The navicular and calcaneal surfaces are separated by a deep furrow in the Asiatic, but not apparently in the African; nor is it the case in three cuboids of the Mammoth, in which the calcaneal facet is perfectly horizontal.

The cuboid, No. $\frac{C}{229}$ Brady Collection, from Ilford, misprinted in the Catalogue as a meso-cuneiforme, is $3{\cdot}4 \times 2{\cdot}2$ in its shorter diameter. It is considerably below the average of Arctic specimens, but adds to the overwhelming evidence, already adduced, of the small race which lived in South-eastern England during the deposition of the brick-earths and gravels of the Thames Valley.

External cuneiforme.—The only point worthy of record in connection with this bone is the absence of the anterior facets for the middle cuneiforme in the majority of specimens of the Asiatic; but there are exceptions, as shown in the cuneiforme, No. 2543, of an old Elephant from India, in the Museum of the Royal College of Surgeons of England, where the two facets are present, as in the African, 708 H, B. M. In the Mammoth, as far as a few instances show, this facet is wanting.

Middle cuneiforme.—This bone varies, as does the next, in configuration and characters of the facets, showing that there is seemingly considerable individual irregularity, both in the recent and extinct species. The points of difference are fully noted in my Monograph on the Maltese Fossil Elephants.[2] These refer to the apex being more

[1] Plate ii, fig. 10.

[2] 'Trans. Zool. Soc. London, vol. vi, p. 87.

round in the young of the Asiatic Elephant and the full-grown Mammoth, as compared with the adult Asiatic and the African, in which the tip is curved, and the greater concavity on the anterior articular surface in the Asiatic and Mammoth as compared with the African. Two cuneiforme bones, from Grays, Essex, gave respectively dimensions as follows:—No. 36,612, B. M., is $3\frac{1}{2}$ by 2 inches in breadth, No. 36,613, B. M., is $3\frac{1}{4}$ by $1\frac{1}{2}$ inches. These, I apprehend, might belong to *E. antiquus*.

I have not seen the *internal cuneiforme* of the Mammoth. A specimen referable to *E. meridionalis* will be noticed in the sequel.

Metatarsus.

First digit.—I have not seen the *first pedal digit* of the Mammoth. There are some apparent differences between the first digits of the two recent species with reference to the configuration of the shafts, the upper surfaces being more convex, and the lower more concave, in the Asiatic than in the African Elephant.

Second digit.—There does not seem much to note in regard to this element of the foot as compared with that of other Elephants. The *second metatarsal* in the Mammoth is usually about 4 inches in length, with a similar girth at the middle of the shaft. Its proximal phalanx has the tarsal union broader and more even in the Mammoth and Asiatic Elephants than in the African, in which it is broad. The bone is more symmetrical in the two former, with the scar for the internal cuneiforme very pronounced in the Mammoth.

Third digit.—The *third metatarsal* is not unfrequently 8 inches in length in the Mammoth. Its characters are much like the recent Elephants, with a few minor distinctions of the shaft in the former, Meridional, and Asiatic, as compared with the African; these, however, may not be persistent.

Fourth digit.—There is little to note of importance as compared with other species. The cuboidal facet of the metatarsal partakes of the character of the Asiatic bone in being less even than in the African. The usual length in the Mammoth is about 4—5 inches.

Fifth digit.—The same characters of the shaft obtained in the *fifth metatarsal* as in the equivalent bone of the fore foot; but otherwise I can perceive nothing of any very appreciable value, unless that possibly the cuboidal facet, as in the Asiatic, is more circular than in the African, and the same appears to be present in the huge bones from the Forest Bed; the dorsal surface, however, is broad and rounded, as in the African. The small articular facet on the inner aspect of the distal extremity is not always present.

The first phalanx is apparently larger and more compressed at midshaft in the Mammoth and Asiatic than in the African, and the irregularities as regards the other phalanges referred to in connection with the fore foot seem more or less common to the hind foot.

MOLARS OF *ELEPHAS PRIMIGENIUS* RECENTLY DUG OUT OF THE FOREST BED.

Since the publication of the last portion of this Monograph on the dentition and scapula of the Mammoth, I have examined at Cromer several molars in the possession of Mr. Savin, junr. These teeth, I am assured, were dug out of the Forest Bed at Overstrand, near Cromer,[1] by his father and himself.

The entire and more important specimens of Mr. Savin's gatherings are—

1. A second or penultimate left lower milk-molar, No. 2 of the Collection. It holds $x\,6\,x$ in $2{\cdot}5 \times 1{\cdot}4$ inches. All the plates are well worn. There is very fine crimping of the machærides, and the spaces between the discs are somewhat wider than ordinarily appears in Mammoth molars, with a slight tendency to central expansion. Taking the characters, however, generally, the tooth is undistinguishable from the generality of the same member of the series in *E. primigenius*.

Admitting the objections to milk-molars generally as suitable for diagnostic purposes, as formerly indicated, the above, *per se*, might be doubted, but the following, I think, may be considered as affording more conclusive evidences.

2. A left upper first true molar, the crown and profile views of which, natural size, are shown in Pl. XXI, figs. 1 and 1 *a*, was removed from the pebbly stratum of the Forest Bed at Overstrand, Cromer, by Mr. Savin. The hardened matrix is still seen adhering to its sides (fig. 1 *a*). It is No. 195 of Mr. Savin's Collection, and holds $x\ 11\ x$ in $5{\cdot}4 \times 2{\cdot}5$ inches, and five ridges in a space of 2·4 inches. The height of the ninth ridge is 3·8 and of the tenth 4·1 inches, and the eleventh is 4·2 inches. All the ridges, with the exception of the posterior talon, are in wear, and the crown (fig. 1) shows the sculpturings very distinctly, although the discs are not fully developed by wear.

The plates are crowded, with no tendency to mesial expansion and angulation of the enamel, as often seen in the broad-crowned variety of *E. antiquus*. There is, however, decided crimping of the enamel in the anterior discs, as occasionally appears in undoubted molars of the Mammoth.[2] Had this tooth been found in Post-Pliocene strata, no competent authority would hesitate in pronouncing it to have belonged to the latter species. The crown shows rather thin enamel as compared with the Ilford molars, and it is not so attenuated as in many Arctic and British specimens. The breadth to the height is

[1] Mr. Savin deserves the thanks of palæontologists for the zeal with which he prosecutes his searches after the fossil animal remains along the neighbouring coast. I am, moreover, under obligations to Mr. Savin for his invariable kindness in permitting me to make use of his specimens for illustration or description.

[2] See Plates XI, XIII, and XIV.

another character appertaining to the Mammoth; in fact, the diagnosis of its equivalent molar could scarcely be better illustrated than by this specimen.

A deep ragged groove will be seen running along the rim of the crown (fig. 1 *a*), with numerous pits marking the margin of the gum and a "caries" condition, which had commenced early, as the tooth is only about one-third worn.

3. Another specimen (Pl. XX, fig. 3) shows the fragment of a crown on the point of being shed; it confirms the condition of the machærides observed in Pl. XXI, fig. 1. Here, again, although the plates are nearly worn out, there are none of the pronounced central expansions and angulations which are so generally well developed in teeth of this size in *E. antiquus*. The enamel is very thin and finely crimped.

4. Another entire left lower FIRST true molar, No. 5 of Mr. Savin's Collection, from the same situation as the two preceding, holds *x* 12 *x* in $6\frac{1}{2} \times 2$ inches, and five ridges in 3 inches, and presents all the characters of the foregoing.

The above, when compared with molars of *E. primigenius* from the Norfolk Coast, and supposed to belong to Post-Pliocene deposits, present no appreciable differences whatever. This view is pointedly sustained by the tooth ascribed by Falconer[1] to the *Pre-Glacial* Mammoth, and referred to at p. 118, so that the evidence advanced by him is, to my mind, as fully established as that of any of the other remains belonging to the so-called Forest-Bed Series. Moreover, when the teeth and bones belonging to the other two Elephants are advanced as exponents of their specific distinctions, and the fact that all are met with in the same deposits, one can scarcely admit that they represent individual or race characters of one extremely variable species. Wherever the evolution of these three distinct forms took place it seems to me, as far as materials extend, that the characteristics here pointed out entitle them as much to the rank of species as is claimed by their living representatives. I can now have no hesitation in admitting the Mammoth among the *Pre-Glacial* Mammals of the British Islands. This conclusion, advocated by Falconer and combated by Boyd Dawkins, but ultimately accepted by the latter, clears the ground, it appears to me, for further researches into the chronology of one of the most widely spread Mammals of the Tertiary Period.

FURTHER ADDITIONS TO THE DENTITION OF *ELEPHAS ANTIQUUS*.

The magnificent molars shown in Plate XX, figs. 1 and 2, are two of four entire teeth belonging to the same individual. They were dug out of the submerged FOREST BED at Corton, near Yarmouth, after one of the heavy gales which tear up the deposits and wash bones and teeth ashore. From the perfect state of preservation of the specimens and absence of any rough usage, I apprehend that they were discovered *in situ*.

[1] Op. cit., vol. ii, p. 170.

They are now in the possession of J. J. Colman, Esq., M.P., of the Clyffe, Corton, Lowestoft, to whom I am indebted for his kindness in permitting me to describe and illustrate them in this Monograph.

It will be seen at a glance that they answer in every respect to the characters I have elsewhere laid down as diagnostic of the broad-crowned variety of *E. antiquus*.[1] The contrast between the above and Plate V, fig, 1, of *E. antiquus* (with the exception of the angulations, which, however, as before stated, are often wanting, and not fully developed on newly invaded crowns) is striking; on the other hand, compare the narrow crowns of the same species in the Plates II, III, and IV.

The colossal dimensions of the former owner of these teeth makes the diagnosis of the bones met with in the Forest Bed doubly difficult, seeing that, although *E. meridionalis* appears to have invariably exhibited gigantic proportions as compared with the usual remains of *E. primigenius*, the fact that teeth of *E. antiquus* are not uncommon, even in Post-Glacial deposits, of the dimensions of the largest specimens referable to *E. meridionalis*, must materially affect their diagnosis, not only on the score of size, but to a great extent as regards their specific characters.

Dr. Falconer laid no little stress on the thickness of the plates and enamel as characteristic of *E. meridionalis;* but, as I have shown, and as he admitted by the recantation of the so-called *E. priscus*, these conditions may exist in *E. antiquus*.

Alluding to the above ultimate molars in Mr. Colman's Collection, they represent the right and left upper and lower. All show exactly the same condition of wear and clearly belonged to one individual. The lower molars were accidentally broken across since their removal from the deposit, but can be reunited without any detriment to measurement.

I have selected the right upper and left lower as being in every way the more perfect specimens. The following are their characters:

Upper molars.—The tooth of the right side (fig. 2) is encrusted with matrix, and its substance is in a perfect state of petrifaction. The two anterior talons have been broken across near their middle quite recently. These are followed by another pair, which take their origin about the middle, and are succeeded by the hollow shell, which characterises teeth with crowns one third detrited. The tooth holds *x* 20 *x* in 13×4 inches.

The remarkable breadth of four inches is noteworthy, as compared with *E. meridionalis*.

The posterior talon is a single digitation and an inch in height. There are eight digitations along the inner sides of the last eight ridges, as if the tooth had been bent on itself in the germ state—a condition referred to as existing in the molar of *E. primigenius*.[2]

There are five ridges in three and a half inches.

The height of the thirteenth colline is 7 inches.

[1] Page 32. [2] Page 121.

The tooth of the left side repeats these characters and dimensions, and has the lateral and accessory digitations more pronounced.

Lower molars.—The right lower molar (figs 1 and 1*a*) is considerably arcuated and tapers towards the heel. It has been recently broken across at the fourteenth plate. The crown holds *x* 20 *x* in 16 × 4 inches,[1] and as regards length is the largest molar of any Elephant I have seen from British strata. The same great breadth is likewise exhibited. There are thirteen discs in wear.

The height of the thirteenth colline is also 7 inches, and there are five ridges in 4 inches, with the same number of accessory digitations (8) on the inner side, as seen in the two upper and the other left lower molar.

The left molar appears to have an additional ridge and shows a formula of *x* 21 *x*.

Like the other, the anterior fang, which is broken off, was single and curved.

The states of wear are unfortunately not sufficiently advanced to develop the discs to their fullest extent, but they are sufficiently detrited to serve the purposes of comparison with the crowns of the typical *E. meridionalis* as described by Falconer. In the above there is no inordinate excess of cement, so that the plates are closer together, the enamel is fully crimped, and there is a decided disposition to central expansion and angulation of the discs, which doubtless would appear pronounced in a lower transverse section of the teeth.

But the ridge formula of itself shows a difference of fully six ridges over the largest tooth that can be unhesitatingly ascribed to *E. meridionalis*. Falconer has placed the limit of the ridge formula in last molars in that species at *x* 15 *x* which he establishes from an Italian specimen,[1] and, on what appears to me questionable grounds, considers that the unusual number of ridges of this specimen may be owing to an abnormal condition of the crown. But I cannot see that there is any reason to establish a limit to a ridge formula, because the ordinary number of ridges seldom exceeds *x* 13 *x*. This view, so pertinaciously carried out by him, has been shown in the two previous parts of this Monograph to admit of so many exceptions that I see no reason whatever to doubt that the same may have obtained in *E. meridionalis*. The above addition to the dentition of *E. antiquus* necessarily alters the ridge formula of *E. antiquus* given at page 47 as follows:

I.	II.	III.	IV.	V.	VI.
x 2 *x*—*x* 3 *x*	*x* 5 *x*—*x* 7 *x*	*x* 8 *x*—*x* 10 *x*	*x* 9 *x*—*x* 12 *x*	*x* 12 *x*—*x* 13 *x*	*x* 15 *x*—*x* 20 *x*
x 3 *x*—	*x* 6 *x*—*x* 8 *x*	*x* 9 *x*—*x* 11 *x*	*x* 11 *x*—*x* 12 *x*	*x* 12 *x*—*x* 13 *x*	*x* 16 *x*—*x* 21 *x*

[1] In connection with a neighbouring locality, MUNDESLEY, there is a description of a beach specimen by Mr. Henry Baker in the 'Philosophical Transactions' of 1745. The molar referred to was 2 feet 11 inches in longitudinal circumference, linear length 15 inches, height 7 inches, and breadth 3 inches. It contained sixteen ridges with enormous discs "furrowed like a millstone." From its height and ridge formula this may have belonged to the broad-crowned variety of *E. antiquus*. A thigh-bone measured 6 feet in length.

[2] Op. cit., vol. ii, p. 117.

There are in the Norwich Museum two fragmentary specimens of molars of the broad crowns of *E. antiquus* besides those described in p. 32. I refer especially to two lower last molars, Nos. 19 and 20 of Miss A. Gurney's Collection. These two teeth belonged evidently to the same individual, but are unfortunately not quite entire. They were dug out of the Forest Bed, Bacton, and are covered with pebbles cemented to their crown and sides. The right molar has only two ridges invaded with a loss behind of several ridges. The crown is much arcuated, as in the Corton teeth, and holds x 18 in 12 inches, with a maximum breadth of 4 inches, and has five ridges in 4 inches.

The height of the eighth colline is 8 inches. The digitations, as in the Corton teeth, are large and numerous, and rival completely anything of the kind found in the teeth of *E. meridionalis*, at all events as met with in British strata.

The resemblances between the crowns of the above and other specimens of the broad-crowned variety of *E. antiquus* and the same tooth in *E. primigenius* I candidly admit are striking; indeed, a comparison between the teeth from the Forest Bed referred to the latter, and the foregoing, as shown in Pls. XX and XXI, complicates the inquiry. Mr. Gunn, F.G.S., long habituated to the discrimination of the Forest Bed remains, has frequently pointed out to me these resemblances in specimens in the Norwich Museum, and were it not from the evidence I have adduced of the connection between the broad-crowned variety of *E. antiquus* and typical molars of that species at p. 31, I feel bound to state that these similitudes between teeth of *E. antiquus* and *E. primigenius* are very close indeed. But, on the other hand, when, as I have shown from abundant material, the narrow, thick-plated, and broad crown of molars of *E. antiquus* can be clearly differentiated among the vast numbers of specimens which have come under my notice, I am constrained to believe that the three varieties belong to one species. That there was any intercourse between the Mammoth and *E. antiquus* in Pliocene or Post-Pliocene we have no proof whatever, and no precedent to establish such a belief, and consequently, after a lengthened and careful survey of the remains of the British fossil Elephants, I feel justified in placing the molars just described with those of *E. antiquus* and the allied teeth described at p. 32.

The thick-plated tooth which puzzled Falconer at first, and caused him to correlate it with *E. priscus*, of Goldfuss, until further instances showed it to be only a variety of *E. antiquus*, and of the broad and thick-plated crown, described at p. 33, is further illustrated by two noteworthy examples I have examined lately. They were dug up on Whittlesea Mere, Cambridgeshire, and are now in the Museum of Zoology, Cambridge University. These two lower molars are not quite entire, but evidently belonged to the same individual. The more perfect specimen holds thirteen plates in as many inches; as far as characters and dimensions extend, they are quite undistinguishable from their colossal companion, just referred to, from Culham, near Oxford, the enamel being also deeply crimped, with the usual central expansions and angulations of the crown of *E. antiquus*. For comparison with these interesting molars there is a portion of a mandible from Whittlesea, in the

Woodwardian Collection of the above University. It contains two entire ultimate molars, typical of the long narrow crown, the ridge formula of each being x 16 x in $12 \times 3{\cdot}8$ inches. This jaw is stated to have been found "below peat." I have, moreover, examined lately, in Mr. Savin's Collection, a fragment of a very narrow, but very thick-plated first true molar, obtained by him from the Forest Bed, Overstrand, near Cromer. It contains x 12 in $9 \times 2{\cdot}5$ inches. These seem to approach the tooth of *E. Africanus*, as further illustrated by the specimens on which Falconer founded his so-called *E. priscus*,[1] and others recorded at p. 33 *et seq.*, and notably by the interesting molar discovered by Professor Ramsay near Tangier,[2] in the land of the African Elephant. The reciprocal relations of these links in the chain of evidence are bound together by further instances adduced in this Monograph, and seem to me extremely suggestive as showing the evolutionary characters of *E. Namadicus*, *E. antiquus*, *E. Africanus*, and the Maltese fossil Elephants on the one hand, and of *E. primigenius* and its allies on the other; whilst in *E. meridionalis*, although, as far as yet known, it does not seem to tend so markedly towards any of them, still, as I shall point out, there are indications of a passage between certain molars of this species and the thick and broad crown of *E. Namadicus* and *E. antiquus*.

ELEPHANTS OF THE RED CRAG OF SUFFOLK.

The Proboscidean remains from the Red Crag present more specimens of Mastodon than Elephas; nevertheless fragments of molars of the latter have been found, but seldom more than a few plates in juxtaposition. Like the other animal relics, they show clear traces of having been much rolled, and are usually highly silicified and discoloured by the ferruginous matrix of the bed. These remnants are not uncommon in public collections—to wit, British Museum and Museum of Practical Geology, and in private collections also.

Falconer identified *E. meridionalis* and *E. antiquus*,[3] but I am not aware of any indications of *E. primigenius* having been found; indeed, as far as my own observations extend, I have been unable to meet with a specimen clearly assignable to *E. meridionalis*, inasmuch as all the transverse sections of discs present thick enamel central expansions and frequently pronounced angulations of the thick-plated (*E. priscus*), variety of *E. antiquus*, as appears from the following:

1. The fragments of crowns (Pl. XXVI, figs. 2 and 4) from Red Crag diggings at

[1] Op. cit., vol. ii, p. 96.

[2] 'Journ. Geol. Soc. London,' vol. xxxiv, p. 515, fig. 9.

[3] Op. cit., vol. ii, p. 206.

Trimley, near Felixstow, Suffolk, were lately presented to the Museum of the Yorkshire Philosophical Society, by Mr. W. Reed, F.G.S., who has kindly forwarded the specimen for description and illustration in this Monograph. Fig. 2 represents three incomplete discs, showing the decidedly central expansions and angulations of the thick-plated crown of *E. antiquus* (p. 33, and Pl. V, fig. 1), but the enamel is free from crimping and all the elements are in excess, as in *E. meridionalis*, in which, as before observed, the two former conditions sometimes occur in individual plates, although rarely on successional discs, as shown in Pl. XXVI, fig. 2.

As in the case of the majority of fragments of thick-plated molars, it is quite impossible to give a decided opinion. However, in consideration of the above characters, I am inclined to place this example with the thick-plated variety (*E. priscus*) of *E. antiquus* rather than with *E. meridionalis*. Each plate is about an inch in thickness at the middle of the disc.

2. The vertical sections of two plates from the same locality (Pl. XXVI, fig. 4) are quite in keeping with the foregoing.

MONOGRAPH

ON THE

BRITISH FOSSIL ELEPHANTS.

ELEPHAS MERIDIONALIS.

I. INTRODUCTORY.

The differentiation of a species of fossil Elephant distinct from the *Elephas primigenius*, to which all teeth and bones referable to the genus were supposed to belong, was first surmised by Nesti from discoveries made in the Valley of the Arno and the neighbourhood of Rome.[1] Subsequent researches by Cuvier, Croizet, De Blainville, and Owen, are fully detailed by Falconer,[2] and the more pertinent points are referred to in the previous parts of this Monograph; suffice it to state that, whilst Nesti and Croizet maintained the specific identity of *E. meridionalis*, the three other palæontologists adhered to the opinion that the evidences he had adduced were not sufficient. It was left to Dr. Falconer, in 1844, when engaged in studying the Proboscidean remains collected by himself and others in Northern India, to correlate certain characters of the molars with those of similar relics from British strata. The result of these comparisons he has embodied in the Essays I have so frequently referred to in this work.

In his classification of the Proboscidea from their forms of dentition, he includes the *E. meridionalis* with *E. planifrons*, of India, *E. priscus* (a species he subsequently withdrew as being only a variety of *E. antiquus*), *E. Africanus*, and *E. Melitensis*, in his sub-genus Loxodon, which he again subdivides into two groups, distinguished by their well-marked dental characters. Thus, *E. meridionalis* and *E. planifrons* have the "colliculi grossè digitati, adamante crasso," and differ in these respects from all other Elephants. The value he attached to the teeth alone as diagnostic of species of Proboscidea is apparent throughout all his writings; and, as I have elsewhere observed, his system of taxonomy is formed entirely from dental conditions, as shown by the distinctive characters of the three sub-genera Stegodon, Loxodon, and Euelephas. I have already[3]

[1] 'Annale des Museo di Firenze,' tom. i, et 'Nuovo Giornale de Letterat.,' tom. xi.

[2] 'Palæontological Memoirs,' vol. ii, p. 104.

[3] Page 78 and elsewhere.

expressed a belief, from studies of molars of the *E. antiquus*, *E. primigenius*, and other species, that he often exercised a far too rigorous observance of the characters of these sub-genera in his differentiations of the ridge formulæ of species, thereby reducing the often wide extremes to a mean which cannot fairly be said to express the ridge formula of the tooth in question, as is well exemplified in the case of the ultimate molar of *E. primigenius*,[1] and numerous other instances. Moreover, I find, as far as the materials I have examined are concerned, that the evidences afforded by the teeth of *E. meridionalis* support these inferences deduced from the dental elements appertaining to the other extinct and recent species.

II. DISTRIBUTION.

Both the geological and geographical distribution of *E. meridionalis* generally, and in the British Islands in particular, are much more limited than is the case with either of its two congeners. As far as this so-called Meridional Elephant is concerned, it has only been found hitherto in what is known as the "Forest Bed," or submerged fluviatile and fluvio-marine deposits, which form the bottom of that portion of the North Sea extending along the shores of Norfolk, Suffolk, and Essex, as shown in Map, Pl. XXVII.

The absence of its remains in any British deposits more recent than the Pliocene period accounts for the disparities of distribution between it and the two other extinct species, as shown in Maps, Pls. XXVII and XXVIII.

The contemporaniety of the *E. meridionalis* and *E. antiquus* is generally admitted, from numerous discoveries of their remains in the same bed. Dr. Falconer maintained a similar opinion as regards *E. primigenius*,[2] chiefly on evidences deduced from discoveries in Italy; whilst Boyd Dawkins and others refused to admit that the specimens found along the sea-beaches of Norfolk and Suffolk were derived from the Forest Bed, insisting that they were the products of the Post-pliocene strata overlying the latter, and from which they had been washed by the sea. In support of this view several instances were advanced of molars of the Mammoth having been dug out of these Post-pliocene strata. At page 72 I have alluded to this subject; and, after a careful survey of the specimens and the writings of authorities, I was of opinion that the existence of the Mammoth prior to the Ice Age had not been clearly proven: but a visit to the coasts of Norfolk and Suffolk during the summer of 1879, and inspections of the specimens described at page 173, together with the evidence of persons who discovered them, leave little doubt on my mind that these teeth and others alluded to cannot be distinguished from typical molars of the Mammoth. The view, therefore, of Falconer, that the three species were contemporaneous, and that the Mammoth was a Pre-glacial Mammal, seems to me more than probable, not only from the

[1] Table, p. 123.

[2] Op. cit., vol. ii, pp. 239 and 587.

late discoveries at Cromer, on the Norfolk coast, but from the proofs adduced previously by Falconer, and the later additions made by Boyd Dawkins.

The geographical distribution of *E. meridionalis*, as far as has been accurately determined, extends from South-Eastern England to France, where it has been found in the northern, middle, and lower Departments. Its existence in Spain has not been confirmed; and, besides the discoveries in Northern Italy and the determination of remains from South-Eastern Europe by Lartet, I am not aware of any well-authenticated discoveries in other European countries.

The circumstances under which the Proboscidean and other Mammalian remains are met with on the shores of East Anglia may be stated as follows:—Occasionally, after heavy gales, or "scours" as they are locally designated, portions of the overlying cliffs and the littoral zone are laid bare and expose the remains *in situ*. At other times, usually at low tides, a search over exposed surfaces between high- and low-water mark is rewarded by discoveries; but by far the greater number of finds are picked up casually along the shore-line after the object has been rolled about and often considerably damaged.

The vast quantities of Proboscidean and other Mammalian remains reclaimed from the coast deposits of Norfolk and Suffolk would, if brought together, furnish a very remarkable collection. Unfortunately, several valuable relics have been dispersed and are not available for study; nevertheless, thanks to the assiduous labours of persons interested in collecting and preserving these specimens for scientific purposes, the Norwich, British, Oxford, Cambridge, and Jermyn-Street Museums, together with several private collections, afford ample evidences of the fauna of the Forest-bed period.

Among numerous benefactors, whose names it seems to me necessary should be placed on record in a Monograph like this, foremost in the ranks stands the honoured name of John Gunn, late of Irstead. This veteran geologist has enriched the admirable Natural History Museum of his native town with the products of a long lifetime devoted to the study of the later Tertiary deposits of Norfolk; and, with an enthusiasm and scarcely diminished vigour of earlier days, he is still labouring in the field where the father of Norfolk geology, Samuel Woodward, made for himself a well-known reputation. Among their fellow-workers may be mentioned Miss Anna Gurney, the Rev. J. Layton, the Rev. J. King, the Rev. J. Green, and Robert Fitch, Esq.

III. FAUNA AND FLORA OF THE FOREST-BED.

The Fauna and Flora of the Forest-bed series are highly suggestive of the character and extent of the submerged area of which they are the exponents. Although the animal remains are in general fragmentary, there is no difficulty in perceiving how very varied were the forms of Mammals which inhabited the land during the deposition of the various strata composing what is termed the Forest Bed. Unfortunately, the varying

nature of the coast-lines of Norfolk and Suffolk, and constant interruptions, interfere very much with attempts to correlate the members of the series, consequently their sequences are by no means accurately determined. Allowing for some diversity of opinion amongst geologists[1] as to the stratigraphical relations, and the fragmentary conditions of the animal remains, the following may be considered a fair summary of the chief Fauna and Flora which existed from the deposition of the lowermost strata up to the commencement of the Glacial formations, as far as has been accurately determined.[2] It is apparent, however, that the list is far from being complete, and that even many of the remains of the Mammals, especially the Ungulates, the most extensive and interesting portion, deserve more attention than has been hitherto bestowed on them.

The Insectivora are represented by *Talpa Europæus*, *Mygale moschata*, *Sorex vulgaris*, *S. fodiens*, *S. remifer*.

The Rodentia by *Castor fiber*, *Trogontherium Cuvieri*, *Arvicola amphibius*, *A. agrestis*, *A. glareolus*, *Sciurus* (*?*).

The Carnivora by *Canis lupus* (*?*), *Canis vulpes* (*?*), *Machairodus*, *Felidæ*, *Martes sylvatica*, *Gulo luscus*,[3] *Ursus spelæus*, *Ursus ferox*, *Trichecodon Huxleyi*, *Phoca*.

Of Proboscidea *Elephas meridionalis*, *E. antiquus*, *E. primigenius*.

The Cetacea by *Monodon monoceros*, and two species of *Balænoidea* are represented by vertebræ.

The Ungulata present many difficulties in the way of accurate determinations. The following have been recorded:—*Equus caballus*, *E. stenonis*, *Rhinoceros etruscus*, *R. megarhinus* (*?*), *Hippopotamus major*, *Sus scrofa*, *Caprovis Savinii*. The Cervidæ are represented by *Cervus megaceros*,[4] *C. capreolus*,[4] *C. claphus*,[4] *C. polignacus*, *C. cornutorum*, *C. verticornis*, *C. Sedgwickii*, *C. bovides*, *C. latifrons*, &c., altogether thirteen species. The majority of the Cervine remains are very fragmentary, and confined to pieces of antlers or portions of the calvarium.

The Invertebrata are represented by *Unio*, *Cyclas*, *Paludina*, *Mya truncata*, *Leda myalis*, besides Insects, all of recent forms, still met with in East Anglia.

The Flora of the period, according to the determination of Heer and Hooker, belong to recent genera and species, such as *Quercus*, *Betula*, *Alnus*, *Prunus spinosa*, *Pinus sylves-*

[1] See Prestwich, 'Journ. Geol. Soc. London,' vol. xxvii. Gunn, vol. xxvi, p. 551.

[2] I am indebted to Mr. E. T. Newton, F.G.S., of H.M. Geological Survey, for a list of the Carnivora and other Mammals. Mr. Gunn has also furnished me with several names. I have also drawn from the writings of Falconer, 'Pal. Mem.,' vol. ii, p. 473.

[3] The Glutton, Marten, and Seal have been lately added to the fauna by Mr. E. T. Newton, 'Geol. Magazine,' vol. vii, 1880.

[4] These species have been retained in lists of the Deer of the Forest Bed on apparently doubtful authority, and seemingly as regards the Irish Elk and Red Deer altogether on the evidences of fragments of antlers, which might have belonged to any of the other large forms. A horn of a capreoloid Deer in the King Collection, Jermyn Street Museum, is said to have been obtained from the coast of East Anglia, but its exact stratigraphical position is not given.

tris et abies, Taxus baccata, and aquatic plants referable to *Potamogeten, Nuphar luteum, Nymphæa alba, Menyanthes trifoliata, Ceratophyllum demersum,* and *Osmunda regalis,* &c.

IV. DENTITION.

The general affinities and distinctions between incisors and molars of *E. meridionalis,* as compared with teeth of *E. antiquus* and *E. primigenius,* have been already noticed,[1] as well as the variations to which they are subject. These comparisons may be summarised as follows:

1. The tusks, in general, present a simple curve, as in the recent species, in both *E. meridionalis* and *E. antiquus,* whilst they are spiral in *E. primigenius,* and generally more slender in proportion.

2. The incisive alveoli are more or less divergent in all, and are variable as to length, breadth, and depth.

3. The molars are very broad in *E. meridionalis* and *E. primigenius,* and are narrow generally in *E. antiquus,* excepting in the broad-crowned variety.

4. The height of the molar has its minimum in *E. meridionalis;* it is higher in *E. primigenius,* and attains to the maximum height in *E. antiquus.*

5. The enamel is thick in *E. meridionalis* and in varieties of *E. antiquus,* whilst it is thin in *E. primigenius.*

6. The enamel borders are rarely crimped in *E. meridionalis;* and, when at all, the plaiting is more often confined to only portions of the margins of odd plates, or presents a slight roughening of the external border and surface, as seen in Plates XXIV and XXV. The main feature is the deep channelling and general unevenness of the enamel. In *E. antiquus* the crimping is generally pronounced, and affects the entire thickness of the enamel with a central angular notch. In *E. primigenius* all these characters are generally absent, the borders of the enamel being usually undulating, without plaiting of any sort, or it is confined to parts of the enamel of a disc.

7. The contour of the worn disc in *E. meridionalis* is generally more uniform in breadth throughout, excepting a tendency in odd discs to central expansion and angulation. In *E. antiquus* there are marked central expansions and angulations. The disc is narrow in *E. primigenius,* and rarely shows any tendency to mesial expansion, and no disposition to form the central notch so prominent in many of the teeth of the latter.[2]

8. The cement-wedges are largest in *E. meridionalis,* less so in *E. antiquus,* and much thinner in *E. primigenius.* In consequence the plates are wide apart in the first, more approximated in the second, and crowded in *E. primigenius.*

9. The terms "thick- and thin-plated molars" I have applied to teeth of *E. antiquus*

[1] Pages 7 and 77.

[2] Plates III and V, *E. antiquus.*

and *E. primigenius* is applicable, but in a much smaller degree, to the molars of *E. meridionalis*.[1] These discrepancies, in several instances, as regards the two former species, seem in some cases diagnostic of races and local varieties, such as the small, thick-plated molar of the Mammoth found at Ilford, in the Valley of the Thames, but I apprehend that, as occurs often in the living species, the crown constituents go frequently hand in hand with unusually large developments of the other portions of the skeleton.

The nearest approach to the elements of the molar and its ridge formula in *E. meridionalis* is in the teeth of *E. planifrons*, of Northern India: indeed, a larger assortment of its remains may show a far closer relationship than can be at present admitted with fairness; moreover, Falconer was so impressed with the similarity between the molars of these two Elephants that he correlated them in the classification of his sub-genus Loxodon.[2]

The above are the more general features of the molars of these three forms, but there is much variability, and the most pronounced divergences from typical molars of each species, or of the three conjointly, may be met with in the same deposits.

1. INCISORS.

An enormous tusk in the Norwich Museum, from the Elephant Bed at Runton, near Cromer, presented by Sir Thomas Buxton, Bart., is broken across in two places, and the tip is wanting; the contour is, however, preserved throughout, but there has been some desquamation of the outermost layers of dentine. The sides are somewhat compressed, whether a natural condition, or from pressure, or from loss of substance does not appear determinable. The arc is about the same as in the two recent species. A portion of the pulp-cavity is preserved. The entire length lineally is 93 inches, and by tape along the lower border 130 inches. The girth at the proximal extremity is 27 inches, and at the distance of 41 inches from the latter 31 inches.[3]

Seeing that the tusk of *E. antiquus* presents the same configurations, and that individuals of the latter attained to nearly the same colossal dimensions, it is impossible to assign the above with certainty to either species; the probability is, however, that it belonged to *E. meridionalis*.[4]

A portion of a tusk dredged from the North Sea about forty miles off Southwold,

[1] The enamel in the generality of well-worn crowns of *E. meridionalis* stands up prominently with both the enclosed dentine and external cement denuded, the latter so much so that the ridges and ribbing of the outer surface of the plate are distinctly seen. This is very apparent in Pl. XXIV, figs. 1 and 2, and in the mandibular teeth in Pl. XXV, fig. 1.

[2] Op. cit., vol. ii, pp. 14 and 108.

[3] This tusk has about the same dimensions and is of the same contour as the specimens of *E. meridionalis* in the Piti Palace, Florence, recorded by Falconer, 'Pal. Mem.,' vol. ii, p. 120.

[4] A fragment from St. Germain is figured by Logard. It shows also a gentle curve, 'Arch. du Mus. Hist. Nat. de Lyon,' pl. xvii.

on the Suffolk coast, is preserved in the collection of J. J. Colman, Esq., of Corton. It is smaller than the above, but presents precisely the same characters, contrasting in these respects with the more slender and highly arcuated incisor of a Mammoth, in this gentleman's possession, from the submarine deposits close to Lowestoft, Suffolk. Considering that the teeth of *E. antiquus* described at page 175, and shown in Pl. XX, figs. 1 and 2, were dug out of the Forest Bed in the neighbourhood, it is just possible that the tusk may have belonged to the same individual.

I have seen no milk-incisors referable to any of the three species.

2. MILK-MOLARS.

Ante-penultimate Milk-Molar.

I can find no reference whatever of this tooth having been found in British strata.

The examples given by Falconer[1] are from the Valley of the Arno. An upper molar is recorded to be 0·95 inches in length by 0·75 in width, and a lower is 0·7 in length, the breadth is not given. Both specimens present a ridge formula of x 3 x. The above dimensions, considered relatively with the successional molars, appear small, and even when compared with the same tooth in *E. antiquus* and *E. primigenius*.[2] The dimensions, however, as already stated in connection with the two latter, vary much, and the crown sculpturing is never so pronounced as to display specific characters. No doubt, however, the plates were thick and the cement in excess as compared with the Mammoth's ante-penultimate milk-molar.

Among the Proboscidean remains from the Sewalik Mountains of India there are numerous molars so closely related in character to teeth of *E. meridionalis*, that had the specimens been found in Europe one would have no hesitation in placing them with the latter; in fact, it was a knowledge of the Sewalik molars, referred by Dr. Falconer to *E. planifrons*, that first led him to surmise the existence of more than one species of fossil Elephant in British strata. In the noble monument of his zeal, and that of his colleague, Colonel Cautley, as evidenced by the fossil remains in the National Collection, and elsewhere, there are several specimens of *E. planifrons* with a small pre-molar in front of the milk and true molars; a condition not, as far as is known to me,[3] yet observed in *E. meridionalis* or any other member of the genus. It is clear, however, from several jaws in the Sewalik Collection, British Museum, that the presence of a pre-molar was not an invariable condition in *E. planifrons*.

[1] Op. cit., vol. ii, pp. 110 and 114.

[2] Pages 11, 86, and 88.

[3] Falconer notices the point, op. cit., vol. ii, pp. 93 and 118.

Second or Penultimate Milk-Molar.

The specimens described by Falconer as illustrative of this molar deserve notice. Having examined and compared them carefully with equivalent teeth of allied species, I do not quite agree with the diagnosis established by him.

No. 4, Norwich Museum, is stated by Falconer to belong to the upper jaw.[1] This I am unable to endorse, as the specimen is so much altered from rolling on the beach that the original contour is completely lost, and therefore it would be difficult to say to which jaw it originally belonged. Neither in its ridge formula *x* 6 *x*, nor dimensions $2{\cdot}6 \times 1{\cdot}4$ inches, nor in the relations between the crown constituents, are there any confirmatory evidencies to assign it to any particular species. It can therefore scarcely be accepted as diagnostic of the second milk-tooth of *E. meridionalis*.

No. 6, Norwich Museum, is figured and described by Falconer.[2] This tooth, no doubt, is from the lower jaw. The dimensions are $3 \times 1{\cdot}4$ inches, and the ridge formula *x* 6 *x*. The crown is unusually broad to length. There are, however, *mesial expansions* of the discs, *angulations*, and *crimpings* of the machærides, which are more in keeping with *E. antiquus*. Its large size is its best recommendation, but it appears to me hazardous to accept it as a tooth of *E. meridionalis*, excepting on the score of dimensions.

The fragment of a right ramus and its detached crown, No. 214, Gunn Collection, Norwich Museum, holding an entire second milk-molar *in sitû* (Pl. XXII, figs. 3 and 3 *a*), present the following characters:—This tooth is $3 \times 1\frac{1}{2}$ inches in its greatest breadth, and holds a ridge formula of *x* 6 *x*.

Although a label by Dr. Falconer is attached to the jaw, and records its position in the dental series in his own handwriting, I cannot find a reference to it in his works. The crown pattern, as far as the sculpturing of the enamel is concerned, is of no value, seeing that the machærides show crimping; but the excess of cement, large dimensions, and the fragment of jaw are certainly in favour of its belonging to the *E. meridionalis*, or else to a huge individual of *E. antiquus*.

As regards the ramus, there is a small pit in front of the tooth, evidently the remains of the socket of the ante-penultimate molar. The reclination of the dip of the diastema is also a character of some importance; it is 4 inches in length. The thickness of the jaw, which is 3 inches in breadth at the heel of the molar, and the height of the ramus, which is $3\frac{3}{4}$ inches in front of the tooth, indicate greater proportions than generally prevails in the Mammoth, and, at all events, in the Post-glacial specimens of *E. antiquus* met with in British strata.

A left lower molar, in Mr. Fitch's Collection, from the "Freshwater deposits" at "Mundesley," holds *x* 6 *x* in $2\frac{3}{4} \times 1\frac{1}{2}$ inches. The crown is commencing wear, and

[1] Op. cit., vol. ii, p. 133.

[2] 'F. A. S.,' pl. xiv B, figs. 3, 3 *a*; 'Pal. Mem.,' vol. ii, p. 134.

although all the ridges, excepting the posterior talon, are invaded, only the first two have their digitations worn out. The enamel has the usual undulations common in such teeth, but there is *no* crimping of their machærides. The posterior fang is very broad, being $1\frac{1}{4}$ inches; the anterior fang is lost. There are five ridges in 2 inches.

The size is in favour of the tooth being that of a large species of Elephant, the grossness being consequent on thicker wedges of cement than ordinarily obtain in *E. antiquus* and *E. primigenius*, and there is an absence of crimping.

This tooth supports the characters of the true molars of *E. meridionalis* much better than any of the preceding.

Another right lower molar in the above-named gentleman's Collection, from Cromer, has the cement denuded. It is smaller, with a ridge formula of $x\ 6\ x$ in $2\frac{3}{4}$ by 1·2 inches in breadth. Here five ridges are contained in a space of 2 inches. The excess of cement and the large dimensions are the important points in the diagnosis; whilst the crimping of the enamel machærides of the discs are, on the other hand, in favour of *E. antiquus*. I repeat, however, that the second milk-molar *per se* is not always a reliable element in the diagnosis of species.

These are all the entire teeth belonging to the above member of the milk-series that have come under my notice.

I have examined several fragmentary specimens; but, with the exception of the foregoing, none are convincing as regards their association with *E. meridionalis*.

The molars, from Tuscan deposits, representing this stage of the dentition of *E. meridionalis* are fully described by Falconer.[1] The ridge formulæ and dimensions of entire penultimate teeth may be thus briefly recapitulated: upper, $x\ 6\ x$ in $2{\cdot}5 \times 1{\cdot}6$; lower, $x\ 6\ x$ in $2{\cdot}4 \times 1{\cdot}5$ inches.

The Ultimate Milk-Molar.

This tooth in *E. meridionalis* holds a ridge formula of $x\ 8\ x$. Referring to the examples from British strata referred to by Falconer,[2] I find No. 10 of the Norwich Collection is, like No. 4, a previous member of the series, much detrited from rolling in the surf. The formula may have been $x\ 7\ x$, but the posterior talon is wanting, and the anterior talon and first plate are not well defined. It is evidently a lower jaw tooth, and of the left side. The length is $3{\cdot}9 \times 2$ inches. As a typical example it is defective, and neither in the worn crown nor in its elements do I find sufficient characters to distinguish it from *E. antiquus*.

In the same Collection is a left upper molar (No. 9) nearly entire, from the "Iron Pan, Forest Bed, Bacton," Norfolk coast. The specimen was presented by Miss A. Gurney. It is $4\frac{1}{2} \times 1\frac{3}{4}$ inches in breadth, and holds a formula of $x\ 7\ x$. All the ridges

[1] Op. cit., vol. ii, pp. 110 and 114.

[2] Op. cit., vol. ii, p. 134, and 'F. A. S.,' pl. xiv B, figs. 4 and 4 *a*.

are in wear, excepting the posterior talon; here the cement is in excess, and the discs have *no* crimping to any very marked extent; for the most part, the latter is confined to the outer borders.

The tooth is decidedly distinct from the usual crowns of *E. antiquus*, with which, I imagine, it could scarcely be confounded. This molar seems to me distinguishable from the equivalent molar of either of the other two British fossil Elephants.

In Mr. Alfred Savin's Collection at Cromer, I examined a left lower molar (No. 12) of nearly the same size as the above, having precisely similar characters. It holds $x\,7\,x$ in 4×2 inches, and five ridges in $2\frac{1}{4}$ inches. The first three ridges only are invaded, so that in neither were the digitations worn out. The characters, however, are in keeping with the foregoing, with which it appears to me to claim relationship.

A small lower molar in the King Collection, Jermyn Street Museum, from the Forest Bed, Cromer, shows five discs with irregular outlines. The enamel is thick, uncrimped, with thick wedges of dentine and much intervening cement. The crown widens in front, being 2 inches in breadth, maintaining an increase to the middle of the crown, when it rapidly narrows posteriorly, being 1·4 inches behind. The ridge formula is $x\,7\,x$ in $4{\cdot}8 \times 2{\cdot}8$ inches. In its thick plates, absence of crimping and of central dilatation, with the usual channelling of the enamel border, the above follows its predecessor. On the label is written, "Green band and no gravel," indicating the particular stratum from which it was obtained.

Another, No. $\frac{\text{G}}{92}$, in the above Collection, from the same situation, but of the upper jaw, is shown in Pl. XVII, fig. 8. It holds $x\,8\,x$ in $4{\cdot}5 \times 1{\cdot}4$ inches. Here six discs are in wear, with a well-marked pressure-scar in front. It is from the "Green band and gravel of the Forest Bed."

Of foreign specimens of the last milk-molars presenting characters comparable with the foregoing, there is a fragmentary molar, left side, lower jaw, from the Val d'Arno, in the British Museum. It is No. 38,824. The anterior talon appears to be wanting, leaving a formula of $8\,x$ in $5 \times 1{\cdot}7$ inches, and six ridges in 3 inches. The crown is considerably arched and narrow, with seven discs in wear, showing characters in keeping with the preceding molars. But whether this is an unusually large last milk, or small first true, molar, may be considered doubtful.

The Italian specimens illustrative of the third milk-molar are recorded as follows by Falconer:—Upper, $x\,8\,x$ in $4{\cdot}6 \times 2{\cdot}5$; lower, $x\,8\,x$ in $4{\cdot}6 \times 1{\cdot}8$, $x\,8\,x$ in $4{\cdot}7 \times 1{\cdot}85$, and $x\,7\,x$.[1]

[1] Op. cit., vol. ii, pp. 111, 115.

3. TRUE MOLARS.

The Ante-penultimate or First True Molar.

The first true molar, according to Falconer, is represented by No. 8 of the Norwich Museum, from MUNDESLEY.[1] It contains *x* 8 *x* in 5·3 × 2·3 inches, and is a left lower molar. Dr. Falconer observes: "The discs of the first three ridges are wide and open, but irregularly indented, with a tendency to mesial expansion, and surrounded by margins of thick enamel, which is vertically channelled externally and slightly crimped." Again, "One of the distinctive characters of the species, namely, the low height of the crown in reference to the breadth, is well exhibited."

With reference to the latter, it must be conceded that the character is important in the diagnosis of these large broad teeth from the Norfolk coast, but in the present instance the crown is about half worn down, consequently the width to height makes the contrast. However looked upon, by comparison with similar molars of *E. antiquus* and *E. primigenius*, the above tooth has a relatively narrow crown for *E. meridionalis*. The enamel of the discs is fully crimped, there is mesial expansion, and the plates are not thick. The most that can be said of it is, that the cement is in excess, and the undulations of the enamel ("vertical channellings" of Falconer) carry with them characters different from the ordinary tooth of *E. antiquus;* but the specimen altogether is not representative of points, which appear much more distinct in other instances, I shall describe presently.

Another instance is adduced[2] from MUNDESLEY. It is No. 7 of the Norwich Collection, and belongs to the lower jaw, left side. It is not entire, having only the anterior talon and seven plates in 5·5 × 2·65 inches, and holds five ridges in 3·2 inches.

Falconer says the enamel ridges are "thick." This appears to me by no means the case; indeed, by comparison with other teeth, I should consider them the reverse. He states that some other plates are "disposed to slight crimping and irregular angular expansions." They appear to me to show decided crimping and angular expansion; which even in typical specimens of *E. antiquus* is not always regular. The tooth has much to recommend it rather for the dental series of the latter species than for *E. meridionalis*.

Another tooth, 33,368, B. M., from the same situation, and much rolled, belonging to the lower jaw, left side, holds what appears to be *x* 7 *x* in 5·5 × 2¼ inches, and seven ridges in 4¾ inches. It is unworn, but the cement wedges are thick, and the general grossness of the crown place it, at all events, with the preceding.

[1] Op. cit., vol. ii, p. 134, and 'F. A. S.,' pl. xiv B, figs. 5 and 5 *a*.

[2] Op. cit., vol. ii, p. 135; 'F. A. S.,' pl. xiv B, figs. 6 and 6 *a*.

A highly silicified left upper tooth from Cromer is shown in Pl. XXII, fig. 1. It has been obligingly lent to me by Mr. Fitch, of Norwich, for illustration in this Monograph. It holds *x* 8 *x* in 7 × 3 inches, and five plates in 3 inches. The parts are highly vitrified and in most perfect states of preservation, but it had evidently been rolled, and is consequently a beach specimen. There is a marked absence of crimping, and the cement is in excess; but, on the other hand, there is a tendency to angular expansion of the discs, as in *E. antiquus*, showing characters intermediate between the two. Now, although I have not seen a first true molar of the latter with a lower ridge formula than *x* 9 *x*, there is, however, the evidence of a last milk-tooth of *E. antiquus* recorded in Note 2, page 127, with as low a ridge formula as *x* 8 *x*. Considering, therefore, the rule of succession in last milk and first true molars, the possibility is that such a formula might be found in first true molars of *E. antiquus;* at the same time, I have no hesitation in asserting that the above specimen presents, in its uncrimped enamel and thick cement wedges, features not observed by me in any teeth referable to the latter Elephant. I would select it, therefore, as a typical instance of the first true molar of *E. meridionalis.*

No. 33,376, B. M., from Happisborough, Norfolk, is a left lower molar, considerably arcuated, with only the first ridge invaded. The plates are thick, with large cement wedges, there being six ridges in $3\frac{1}{2}$ inches. The formula appears to be *x* 8 *x* in 5·8 × 2 inches.

The first true molar is illustrated, according to Falconer, by the following specimens in the Tuscan Museum at Florence:—Upper, *x* 9 *x* in 6·2 × 2·4 inches, and *x* 8 *x* in $6\frac{1}{2}$ × (?) inches; lower, *x* 8 *x* in 5·5 × 2·6, and *x* 8 *x* in 6·4 × 2·4 inches.[1]

Second True Molar.

Fragmentary specimens are referred to by Falconer;[2] their broken conditions, however, are against any very certain characters with reference to formula. The crown constituents agree with the data he has laid down as diagnostic of *E. meridionalis*, viz. "wide disc," "large rings of the worn digitations," and "thick enamel;" none of which, however, are so pronounced by any means as in thick-plated teeth of *E. antiquus*. The excess of cement, which, of course, makes the ridges more apart, is very well shown. The fragment is 5·2 inches in length, and 2·9 in maximum breadth, and contains seven anterior ridges, the height of the last being 4 inches.

Falconer cites[3] another portion of a crown to show the "angular flexures that are sometimes seen when the plates are ground down low." I perceive in the original specimen

[1] Op. cit., vol. ii, p. 111.

[2] Op. cit., vol. ii, p. 135; 'F. A. S.,' pl. xiv B, figs. 7 and 7 *a*.

[3] Op. cit., p. 137 'F. A. S.,' pl. xiv B, figs. 8 and 8 *a*.

another feature, viz. the crimping of the enamel is not confined to a roughening, or, as Falconer called it, "spurious crimping of the outer border," but invades the entire thickness. In other respects the excess of cement carries it with the above, but the thickness of the enamel shown in pl. xiv B, fig. 8 *a* of the 'F. A. S.' is not of much value when compared with the thick-plated *E. antiquus;* moreover, the "angular flexures" are often seen in crowns of *E. antiquus,* and apart from the central angulations so characteristic of the narrow crown of that Elephant's tooth.[1]

With reference to another fragment in the Norwich Museum,[2] Falconer observes:—"From being worn low down the plate exhibits a greater tendency to crimping than usual." To whichever form of Elephant this portion of a tooth may belong, it is scarcely possible, as far as my experience goes, to make out any well-marked specific characters between it and that of the thick-plated tooth of *E. antiquus, i.e. E. priscus* variety, indeed, the excessive crimping is fully as much pronounced as in the Asiatic Elephant. The crown surface is irregularly worn, and contains five ridges in 4·2 inches.

The fragment of a heel (No. 3 of the Norwich Museum), figured by Falconer,[3] and stated by him to belong to the last of the series of *E. meridionalis,* is clearly a fragment of a second true molar, showing a well-marked *pressure-scar posteriorly.* As compared with the thick-plated *E. antiquus* it is now of little value, as *thick* annular discs are often fully as large and wide apart in the latter.

Indeed, certain molars of the Mammoth to which I have referred[4] present these characters; moreover, the crimping of machærides is not always absent in large teeth. For example, No. 22 of Miss A. Gurney's collection in the Norwich Museum shows a crown of the above description, and inseparable from the foregoing. Here the crimping is not only confined to the external margin of the enamel, but also invades the entire thickness. The cement wedges are, however, thick; as is the case likewise with the enamel.

The above tooth is not entire, so its exact position in the series is undeterminable; but from some flattening behind (possibly pressure-marks) there may be a probability that it is a fragment of a second true molar. The crown is well worn, showing confluent fangs, and holds eleven and a half plates in $8 \times 3\frac{1}{2}$ inches. It belongs to the left ramus of the mandible. There are five ridges in $3\frac{3}{4}$ inches. It is from Iron Pan of the Forest Bed, Bacton.

Another fragment (No. 364, Norwich Museum), from the East coast deposit, belongs to the maxilla, right side. There is a loss of plates in front, and a well-marked pressure-scar on the heel. The tooth is very typical of the *E. meridionalis,* and possesses all the characters already noted. Every ridge is invaded excepting the last two. Eight and a half plates with the posterior talon are contained in $8 \times 3{\cdot}5$ inches. No. 320, in the

[1] Plate XX, figs. 1 and 2.

[2] Op. cit., vol. ii, p. 136; 'F. A. S.,' pl. xiv B, figs. 9 and 9 *a*.

[3] 'F. A. S.,' pl. xiv B, figs. 12 and 12 *a*.

[4] Page 118.

same collection, from the Iron Pan, Forest Bed, Bacton, is a portion of a right upper tooth, showing a well-marked pressure-scar on the heel, and contains 11 *x* in $8 \times 3\frac{1}{2}$ inches, and five ridges in $3\frac{1}{2}$ inches. None of the digitations are worn out; nevertheless, the plates are thick, and there is an excess of cement; altogether it may be fairly correlated with the preceding.

No. 33,365, B. M., is a fragment of a right ramus of a mandible from Happisborough. It contains about eight ridges of the first true molar with an entire second true molar behind it; the first four ridges of the latter have been invaded. The diasteme is preserved. This jaw has been broken across at the symphysis in front, and in a line with the heel of the second true molar behind.

The second molar is considerably arcuated and holds *x* 10 *x* in $8\frac{1}{2} \times 3\frac{1}{4}$ inches. There is about an inch to every ridge. It is broad behind, being 3·4 inches in width. The crown shows enamel free from crimping, and has the usual excess of cement observed in these uncrimped teeth, whose external margins present some roughening and channelling. The breadth of crown, the length, and the small height are evident characters as compared with the varieties of *E. antiquus;* and the low ridge formula is assuredly significant, inasmuch as I have not met with the same in any second true molar of the latter species.

With reference to the characters of the ramus. The mental foramina are two in number. One at a distance of 1·2 inches from the margin of the diasteme, the other 2·2 inches distant and a short way above the last.

The usual foramen inside the spout is about 1·4 inches from the margin.

The diasteme slopes at about an angle of 45°. The thickness of the jaw at the base of the coronoid is $6\frac{1}{4}$ inches. The rostrum is wanting. In the rather reclinate diasteme the jaw differs from that of *E. antiquus*, and is broadly distinct, of course, from that of *E. primigenius.*

A detached left lower molar (Pl. XXIII, figs. 1 and 1 *a*), No. 33,343, B. M., also from the Norfolk coast, holds apparently a formula of *x* 9 *x*. The anterior talon is like a plate, and so is the posterior, excepting a small prominence on its posterior surface. About five or six ridges of this tooth are invaded. It is somewhat arcuated, with a double anterior fang followed by a coalescence posteriorly. The length is $8\frac{1}{4} \times 2\frac{1}{2}$, and contains eight ridges in about 5·2 inches. It presents the same characters as the last, with which it may fairly claim relationship.

A characteristic specimen of evidently a second true molar in a fragment of a jaw was discovered by Mr. Alfred Savin at Overstrand, Cromer; No. 37 of his collection. It is a right upper molar with a well-marked pressure-scar on the heel. All the plates are in wear. The anterior fang is preserved, but the first ridge has been ground away, leaving eleven plates and a posterior talon in $8 \times 3\frac{1}{4}$ inches. There are five plates in $3\frac{1}{4}$ inches. The uncrimped enamel, the channelling of the latter, the excess of cement, its dimensions and low ridge formula, seem to me to place it with the foregoing.

No. $\frac{28,820,}{A}$ B. M., from Val d'Arno, is apparently a second true molar of the right side, lower jaw. It holds *x* 11 *x* in 10 × 3·2, and six ridges in 5·5 inches. Eight discs are invaded, with large digitations; there is also arcuation of the crown, a character not uncommon in *E. meridionalis*, notwithstanding the usual shortness of its molars as compared with *E. antiquus*.

Falconer gives examples of this tooth in the Tuscan Museum as follows:—Upper, *x* 9 *x* in 9×4, and *x* 10 *x* in 8·75×3·5 inches; Lower *x* 9 *x* in 7·8×3·3 inches.

Logard[1] figures several teeth from Central and Southern France, perhaps referable to *E. meridionalis*, with other crowns decidedly of the type of *E. antiquus*.

Ultimate or Third True Molar.

The fragment of a tooth (No. 7456, B. M.), described and figured by Falconer,[2] is supposed to have come from the "Oyster Beds" of Mundesley or Happisborough, on the Norfolk coast.

This portion of a tooth has all the characters of *E. antiquus* rather than of *E. meridionalis*, to which he has referred it. The anterior fang remains in part with $\frac{1}{2}$ 8 *x*, or nine and a half ridges. There is pronounced crimping of the middle of the discs with a tendency to central expansion. The specimen at all events is unsatisfactory as a typical instance of the last tooth of *E. meridionalis*.

No. 10 A of the Norwich Museum, recorded by Falconer,[3] is another fragmentary molar. The general features of the crown are well shown in his plates, and the characters faithfully described. The only exception I take to his description is the statement that "the plates of enamel are very thick." To me they appear in no way remarkable in that respect in comparison with *E. antiquus*, seeing that teeth of the latter from the above deposits often show much thicker enamel. There is faint crimping along the external borders of the machærides, with pronounced undulations of the enamelled cords. This tooth is altogether characteristic of *E. antiquus*, whose dental conditions not unfrequently connect it with *E. meridionalis* by the absence of deep-set crimping, the undulating enamelled borders, and excess of cement between the plates, together with close relationships of breadth to height and length. This example is unfortunately advanced in wear, with several of the anterior ridges worn away, leaving 9 *x* in 9·2×3·6 inches, so that its original formula is not preserved.

No. 13 A, Norwich Museum, is also described and figured by the same author.[4] The

[1] 'Archives du Mus. Hist. de Lyon,' pl. xv, fig. 4; pl. xxi, figs. 2, 3, and 4; pl. xx, figs. 4 and 5; pl. xix, figs. 1, 2, 3, and 4.

[2] Op. cit., vol. ii, p. 137; and 'F. A. S.,' pl. xiv B, figs. 13 and 13 *a*.

[3] Op. cit., vol. ii, p. 137, pl. viii, fig. 4, and 'F. A. S.,' pl. xiv B, figs. 14 and 14 *a*.

[4] Op. cit., vol. ii, p. 138; 'F. A. S.,' pl. xiv B, figs. 15 and 15 *a*.

remarkable character in this fragment of an upper molar is its breadth of crown, which exceeds any of the broad-crowned variety of *E. antiquus;* the largest of *E. primigenius* I have examined, being 4·9 inches in its maximum breadth.

The bending of the plates backwards contrasts with just the reverse in No. 10 A, although both belong to the same side of the upper jaw. This shows that the character is of little use for diagnostic purposes. The above specimen displays external crimping on the anterior border of the machærides, but not affecting the entire thickness.

The entire lower molar (No. 3, the Norwich Museum) from THORPE, Norwich, was the specimen which first led Falconer to doubt the unity of species of the British Elephants, and is so far interesting.[1] It is a long and bent molar, with the crown scarcely more than touched by wear. The breadth of crown and the thickness of intervening wedges of cement are seldom so pronounced in the thick-plated and broad tooth of *E. antiquus* and its very low ridge formula x 11 x in 11·2×3·8 is quite remarkable as compared with the lowest expression of even the second true molar of *E. antiquus*. The configuration of the tooth appears to indicate the last of the series. There is no pressure-scar, or pronounced flattening posteriorly, which, however, could scarcely appear in its condition of wear. The crown tails off posteriorly, as in all last lower molars. These characters are decidedly in favour of its being that of a distinct form from either of the British species already described, and might well have produced doubts in the mind of one who had already differentiated the characters of its congeners from the Sewalik Hills. The crown fragment, referred to by Falconer,[2] may be correlated with the other teeth with thick cement wedges; but, besides the vertical channellings, it shows some crimping. It has, however, the general appearance of the *E. meridionalis;* but, as in all broken teeth, one cannot always be certain of their diagnostic values, even in such a fragment as that shown in Pl. XVIII, fig. 4, representing a morsel of a huge molar (No. $\frac{G}{102}$ in the Jermyn Street Museum) from MUNDESLEY, where it was dug out of the blue clay of the FOREST BED. Judging from this small portion, the original must have been, indeed, of enormous proportions.

In Mr. Savin's Collection at CROMER, is a large lower left molar (No. 43) holding fourteen ridges; besides a posterior talon there is a loss in front by detrition of not more than a ridge. It is 10×4 inches in breadth, and must have been a stupendous tooth.

No. 12, Norwich Museum, is a superb right lower last molar covered with matrix from the Iron Pan, FOREST BED. It holds x 13 x in 11×3½ inches.

The crown is narrow and considerably arcuated, and has much the aspect of the narrow tooth of *E. antiquus*. The two anterior fangs support the first two ridges. All are invaded excepting the posterior talon. The discs are inseparable in character from the typical crown of *E. meridionalis*. It holds five ridges in 5½ inches.

[1] Op. cit., vol. ii, p. 130, and pl. xiv B, figs. 18 and 18 *a*.

[2] 'F. A. S.,' pl. xiv B, figs. 11 and 11 *a*.

In its narrow crown it presents, even although a lower tooth, an exceptional character, compared with the usual molars of *E. meridionalis;* indeed, but for the absence of pronounced crimping of the enamel, it might stand for a thick-plated tooth of *E. antiquus* of the *C* variety, referred to at p. 33. But then for the last of the series it stands apart from that species on account of its low ridge formula.

Another magnificent molar, presented likewise by Miss A. Gurney, is No. 23 of the Norwich Collection. It is from the same locality, and is a left lower, with apparently the loss of only the posterior talon. It holds *x* 13 in 14 inches by 4 in maximum breadth, and has five plates in $4\frac{3}{4}$ inches. Seven of the anterior plates are invaded.

This molar is quite typical of the broad, uncrimped crown, and channelled enamel of *E. meridionalis*, described by Falconer.

No 21, Norwich Museum, from Bacton, in Miss A. Gurney's Collection, is like No. 12, just referred to, in having a narrow crown. It is also of the lower jaw, right side, and valuable as an aberrant form of tooth. The fangs have coalesced into a keel along the lower surface. The anterior fangs are broken off close to the base. All the ridges, $\frac{1}{2}$ 11 *x*, are in full wear excepting the last plate and posterior talon, and the general contour of detrited surface is convave. Apparently not more than one and a half ridges have disappeared through wear, so that the formula may have been originally *x* 13 *x*, like the above, in $11\frac{1}{2} \times 3\frac{1}{2}$ inches in breadth. The tooth holds five ridges in $5\frac{1}{2}$ inches, and has a projecting heel. The same remarks are applicable to this as to the preceding molar.

No. 24 of the Gurney Collection is also from Bacton. It is a fragment, however, showing *x* 7 in $6\frac{1}{2} \times 3\frac{1}{2}$ and five in $4\frac{1}{2}$ inches. The tooth has been rolled. It is typical of *E. meridionalis*.

A narrow crown of the type of Nos. 12 and 21, and also in the Norwich Museum, is shown in the fragment of a left lower molar, holding 10 *x* in $8\frac{1}{2} \times 3$, and five ridges in 4·5 inches.

There is a loss of several ridges in front, but eight are in full state of wear, and three with their tips entire. The crimping of the outer borders of enamel is pronounced, and the cement is in excess. A narrow crown seems to have constituted a variety in the dentition of *E. meridionalis* as in *E. antiquus* and rarely in *E. primigenius*.[1]

A typical fragment of *E. meridionalis*, holding $8\frac{1}{2}$ plates in $10 \times 3\frac{1}{2}$ inches, is represented by No. 317 of the Gunn Collection. It is a left lower tooth.

Another typical instance is No. 222 of the Gunn Collection, marked by Gunn "from the soil of the Forest Bed, Mundesley." It is encrusted with *débris*, and the discs are obscured by the hard ferruginous cement; nevertheless, it is a fine fragment, and shows fourteen ridges in $12 \times 3\frac{1}{2}$ inches. The same may be said of No. 308 of the same gentle-

[1] Mr. Gunn lately directed my attention to a remarkably long narrow molar of *E. primigenius* said to have come from the Norfolk Coast deposits. The tooth (Plate XXVI, fig. 1) is a second true molar, lower jaw, left side, holding *x* 16 *x* in $8\frac{1}{4}$ inches. The discs display all the ridges in wear excepting the posterior talon. The enamel is thin, but the remarkable narrowness of the tooth is noteworthy, being only $2\frac{1}{4}$ inches broad in front, $2\frac{1}{2}$ in the middle, and $2\frac{1}{4}$ posteriorly.

man's collection, whilst No. 329, a lower left, holds 8 *x* in $8 \times 3\frac{1}{2}$ inches. It shows a long projecting heel which is rare in lower molars of *E. meridionalis*.

No. 330 was dug out of the Iron Pan, Forest Bed, Bacton, by Mr. Gunn, with No. 302, which is a fragment of a tusk showing a gentle curve like that of the recent species. The molar is so encrusted with the Iron Pan as to make it difficult to count the ridges. Apparently there are about fourteen or fifteen, including of course talons, in 13×4 inches. This tooth is of colossal dimensions.

A superb fragment of a left lower molar is shown by No. 311 of the Gunn Collection. The crown is well worn, and displays a depression or fault affecting three central plates in their antero-posterior direction, whereby one half is depressed fully a quarter of an inch below the opposite side, thus indicating a blow when the tooth was fresh. There is a loss of plates in front by detrition, leaving about an inch of the crown bare, followed by 11 *x* in 11 inches by 3·8 in breadth. The channelled border, thick wedges of cement, and general dimensions, show the above to be a typical crown of *E. meridionalis*.

Another instance of such pressure on teeth is well shown on No. 219, being a palate specimen, where fragments of two enormous upper molars, right and left, appear to have been crushed together with great force. Nos. 220, 221, and 223 are also Forest Bed fragments, undeterminable from the foregoing.

The National Collection contains several very characteristic specimens of the last molar, presenting characters precisely like the foregoing. The following entire tooth is suggestive.

No. 33,330, in the Layton Collection from Happisborough, is a left upper molar with seven ridges invaded, but none of the digitations worn out. The crown is somewhat arcuated and short for a last molar of even the upper jaw. It holds *x* 13 *x* in $9\frac{1}{4} \times 3$ inches and six ridges in a space of 3·8 inches. The large wedges of cement, and the breadth as compared with the height and length, are in accord with the foregoing.

No. 46,214, B. M., is a fragment cut across, and the section polished to show the relative proportions of cement to the other elements. It is very characteristic of *E. meridionalis*. The specimen is in the Owles Collection, and is reputed to be from the Dogger Bank,[1] so prolific of remains of *E. primigenius*.

No. 33,354, Plate XXIV, fig. 1, is a right lower entire molar from Happisborough. Nine ridges are invaded, but the digitations are not worn out .The specimen is considerably arcuated, and holds *x* 14 *x* in $12\frac{1}{2} \times 3\frac{1}{4}$ inches, with thick plates and much intervening cement, inasmuch as six plates, including of course their cement, are contained in as many inches or about an inch to each plate.

No. 33,334, B. M., Plate XXIV, fig. 2, is a left upper molar with the anterior talon ground down and a round heel. It holds *x* 14 *x* in $10\frac{1}{2} \times 3{\cdot}8$ inches. The first five discs are fully formed, and show crimping with a tendency to mesial expansion.[2] Six

[1] This statement, however, may be fairly doubted, as I have been informed, on good authority, that the trawlers who furnished specimens for Mr. Owles occasionally trawled on the Norfolk Coast likewise, when on their way to their fishing ground off the Yorkshire coast.

[2] The disposition to central dilatation of the disc, and even the angulations so pronounced in the

ridges are contained in a space of 4·8 inches. The massive size and large quantities of intervening cement maintain its characters with the foregoing, whilst the crimping and central expansion are like the same in the thick-plated variety of *E. antiquus*.

Two last lower molars, right and left, of possibly the same individual, are preserved in the Museum of Practical Geology, Jermyn Street.

The right tooth has the anterior talon and twelve ridges, with a loss of posterior ridges. It is $12 \times 3\frac{1}{2}$ inches.

The left tooth has fourteen of its anterior ridges preserved with anterior talon, but its heel portion is wanting. It is $13 \times 3\frac{1}{2}$ inches.

Each molar holds eight in 7·8 inches.

About five of the anterior ridges are invaded, nevertheless none of the digitations are worn out. The enamel presents the undulatory character of the preceding. The components are all in excess, the cement being conspicuously abundant; but it would be difficult, without a cross section of these teeth, to separate them from the thick-plated molars of *E. antiquus*.

The pebbly matrix of the Iron Pan of the Forest Bed adheres to their sides. These specimens were found by Mr. Andrews in 1860.

Maxillæ and Mandibles containing Molars.

The ramus, Plate XXII, fig. 2, is described, but not figured, by Falconer.[1] It was dug out of the Elephant-bed, or Iron Pan of the Forest Bed, between Mundesley and Bacton, and is No. 215 of the Gunn Collection. It holds portion of the second and the entire ultimate true molar. The ridge formula of the latter is obscured by the cement covering the tooth, which is partly embedded in the jaw. There are four plates remaining of the fifth, and possibly from twelve to thirteen plates besides talons enter into the composition of the ultimate molar.

The enamel of the discs is free from the crimping of *E. antiquus*, and presents an undulating border, but there is a decided tendency to mesial expansion in several discs. The cement is in excess as compared with *E. antiquus* generally, and the ridge formula of the ultimate tooth is far lower than that of either of the other extinct British species.

narrow crown of *E. antiquus*, are met with in *E. meridionalis* from Italian deposits, as is evidenced by a cast (No. 37,337, B. M.) from the Val d'Arno, where a well-worn crown with seven discs shows marked angulations, but the crimping is confined to the anterior borders of the machærides. This tooth presents an excess of cement, so that each plate and its cement occupy about an inch of the basal antero-posterior diameter. Another (No. 37,336, B. M.) upper molar from the same locality has mesial expansion of discs without crimping or angulations; whilst a third (No. 28,820, B. M.) from the same locality contains about ten of the last ridges and a posterior talon in 9×4 inches. It shows not only central expansion of the disc but also pronounced crimping, extending nearly but not quite to the cornua, and is undistinguishable from a well-worn crown of a broad molar of *E. antiquus*. Thus, all these characters of the latter may occasionally appear not only in individual discs, but in several discs of *E. meridionalis*.

[1] 'Pal. Mem.,' vol. ii, pp. 132 and 140.

Add to these the proportions, *i. e.* the length to the breadth and height as compared with them, and the following characters of the mandible, all of which conspire, with the similar fragment to be described, in establishing what may be fairly considered to be characters distinct from *E. antiquus* and *E. primigenius*.[1]

It is unnecessary to detail the measurements of the jaw so accurately laid down by Falconer.[2] I have, however, to offer observations, on, what he observes, are "peculiarities distinctive of this specimen from the lower jaw of the Mammoth,"[3] to which I might add *E. antiquus*. Moreover, these observations are also applicable to fragments to be referred to in the sequel.

1. The lower elevation of the jaw at the anterior extremity as compared with *E. primigenius* and *E. antiquus*, but not *E. planifrons*, with which it agrees.[4]

2. The long and gradual slope of the diasteme into the beak is also a characteristic feature in the above and 215 A, and in *E. planifrons*.[5]

3. The consequent long symphysis resultant of the prolonged diasteme is a good character, but in both these specimens that part is wanting; the outlines, however, tend to support the diagnosis.

4. The greater length of the horizontal ramus, and the height in proportion to the width of the ascending ramus. This is pronounced and well shown in the above, and is conspicuous in *E. planifrons*.[6]

5. The less sudden curve posteriorly at the angle and margin of the ascending ramus. This character is also distinctive, more especially as compared with the same parts in the Mammoth,[7] and is present also in the jaw of *E. planifrons*.[8]

I observe, further, a flattening on the external border of the ascending ramus, the sharp posterior border of which is similar to that of the African Elephant and *E. planifrons*.

The dental canal is also like that of the African, as it opens upwards and backwards, and not directly upwards, as in the Mammoth.

The usual irregularity in size and position of the mental foramina is shown in this specimen, in which there are two nearly in line with each other. One is $1\frac{1}{2}$ inches, and the other 3 inches from the margin of the diasteme.[9] The internal opening in the gutter is about two inches from the beak.[10]

[1] Pages 52 and 134. [2] Op. cit., vol. ii, p. 140. [3] Op. cit., vol. ii, p. 127.

[4] See 'Faun. Ant. Sival.,' pls. xi and xliv. [5] 'F. A. S.,' pls. xxi and xliv.

[6] 'F. A. S.,' pl. xi, figs. 2 and 3.

[7] 'Ossem. Fossil.,' pl. xv, figs. 5 and 6, taken from Nesti's figs. 1 and 2. [8] 'F. A. S.,' pl. xi, fig. 3.

[9] Cuvier, in alluding to a mandible from Tuscany (op. cit., vol. ii, p. 213), conceives that the mental foramina being two in line and not above or below one another is distinctive of the Italian fossil; but, as will be seen in the woodcuts of *E. primigenius*, figs. 4—12, p. 135, there is no rule as to numbers and position of these openings. He refers also to the contour of the beak, which will be seen to be also exceedingly variable.

[10] The "important specimen" referred to by Falconer ('Pal. Mem.,' vol. ii, p. 132), showing "a longitudinal section" of a molar, is, I am informed by Mr. Gunn, not now in the Norwich Museum.

Another interesting specimen (No. 215 A of the Gunn Collection, Norwich Museum) was, according to a label attached to the jaw, "dug out of the Elephant Bed between the Coal and Cart Gaps, BACTON." It is covered with the *débris* of the Forest Bed, and represents a fragment of a right lower ramus containing the diasteme (injured), with the horizontal ramus entire up to the commencement of the ascending portion.

The jaw holds the last five ridges of the second and the first five ridges of the ultimate tooth, presenting a united worn surface of 10 inches in length. The specimen is described by Falconer.[1] I append, however, several measurements.

The remaining five ridges of the fifth molar, and the five ridges of the sixth, are contained in a space of 4·9 and 6·3 inches respectively. The maximum breadth of the crown of the fifth molar is 4 inches, while that of the ultimate is 3·5 inches; the discrepancy in the latter arises from the tooth being not so much advanced in wear as its predecessors, seeing that only four of the five ridges are detrited. The ridge formula is undeterminable, but the massive dimensions of the teeth and their characters are precisely as in the preceding.

The diasteme is injured, but clearly shows that it was not so erect as in the Mammoth and *E. antiquus*. The mental foramina maintain the same irregularity as to position observed in the preceding, and in all Elephants' mandibles; here one foramen is fully two inches from the margin.

The length from the anterior border of the coronoid to the commencement of the diasteme is 10 inches.

The height of the jaw to the alveolar border in front of the coronoid is 7·5 inches.

Length of the diasteme 8 inches.

Breadth of the ascending ramus at its commencement 7 inches.

Height of the jaw at the commencement of the diasteme $9\frac{1}{2}$ inches. Height at the insertion of the coronoid $7\frac{1}{2}$ inches.

The characters of this ramus and its teeth are precisely like the foregoing jaw.

The lower jaw described by Falconer[2] was discovered on a cliff near MUNDESLEY, and is now in the Norwich Museum, to which it was presented by R. Barclay, Esq. It is not so well preserved as the preceding, but contains more of the jaw, seeing that portions of the two rami are preserved. The ultimate molars are present, but much mutilated; nevertheless, wherever these and the jaw admit of comparison, they are quite in accord with the two fragments just described, and doubtless represent the mandible of the same species.

A fourth fragment (No. 368 of the Gunn Collection) from the FOREST BED represents a right lower ramus without teeth, but the sockets of both are entire. The last is just commencing wear, with a deep pit in front, possibly for the anterior fang or else a fragment of the second molar. The coronoid is also nearly entire, with an almost perpen-

[1] 'Pal. Mem.,' vol. ii, p. 133.

[2] Op. cit., vol. ii, p. 140.

dicular anterior border. It is a suggestive fragment as compared with the preceding, especially with reference to the absolute and relative heights of the horizontal ramus at the commencement of the diasteme, and of the ascending ramus, as indicated in discussing the characters of jaw (No. 215 A).

In the collection of R. Fitch, Esq., there is a fragment of a right ramus of the lower jaw, with a last true molar in place. The tooth is much worn in front, but its heel is rounded, and there is no mark of pressure, although it is much advanced in wear, seeing that the posterior talon is in line with the anterior border of the coronoid.

There are ten ridges in wear, with a loss by detrition in front. The elements present the same characters as in the foregoing. The molar is $9\frac{1}{4} \times 3$ inches.

These characters are, in fact, even more pronounced than in the jaws in the Gunn Collection, to wit, a gradually descending diasteme into the beak, whilst the height of the horizontal ramus at the commencement of the diasteme is 8 inches, and at the insertion of the coronoid it is 7 inches. But the jaw, although low in height, is of great breadth, being 5 inches in width at the heel of the molar. The length of the symphysial gutter is $4\frac{1}{2}$, and its breadth in front $2\frac{3}{4}$ inches, with an internal foramen near the latter.

Another right ramus of a mandible from Bacton, Norfolk, is in the possession of Randall Johnson, Esq., of Stalham. It displays a fragment of the second, with the last true molar just commencing wear. The fragment is nearly entire, with the loss only of the condyles and coronoid.

Here, again, the diasteme slopes gradually into the beak, and is 6 inches in length.

The height at the commencement of the former is $7\frac{1}{2}$ inches, and at the insertion of the coronoid 6 inches.

The dental canal looks upwards and backwards, as in No. 215 A, Gunn Collection, just described.

The entire characters of this jaw are in accord with the preceding, but the last molar is unfortunately half hidden posteriorly; however, the first fragment of the second molar is undistinguishable from the teeth already noticed as regards the channellings of the enamel, absence of pronounced crimping, and the presence of large wedges of cement.

A specimen (No. 28 of the Woodwardian Collection) is fragmentary. It is a right ramus lower jaw with portion of an ultimate molar in position. There is a loss of substance immediately behind the molar. The diasteme is injured, and has been partly restored with plaster.

The crown of this molar is arcuated; it holds 11 *x* in $9 \times 3\frac{1}{4}$ inches. There is slight crimping of the machærides, and the cement between the plates is much denuded, so that the discs appear as if raised much above the general level of the crown. The height of the jaw at the commencement of the diasteme is $6\frac{1}{2}$ inches.

The worn discs, as far as they go, are in support of the characters of *E. meridionalis* rather than the broad crown of *E. antiquus*. The specimen was presented by Miss A. Gurney, and is from the Norfolk coast.

A third maxilla, showing a portion of the palate with two molars similar to the last, is seen in No. 3 of the same collection. The teeth contain 11 *x* in $9\frac{1}{2} \times 4$ inches, and converge a little in front, with an intervening space of $3\frac{3}{4}$ inches. The distances between them at the middle and posteriorly being $3\frac{3}{4}$ and 6 inches respectively. The jaw is covered with matrix from the Forest Bed, Cromer, from which it is stated to have been derived. The crowns of the molars are remarkably broad.

The mandible, Plate XXV, fig. 1, was considered by Dr. Falconer to belong to *E. meridionalis*, from a label attached to the jaw with the name in his hand-writing.

It was found in the Forest Bed, Cromer, and now forms one of many treasures in the Woodwardian Museum of Cambridge University. Through the kindness and liberality of my distinguished friend, Prof. McKenny Hughes, I am enabled to furnish an illustration of this interesting jaw. There is a loss of the condyles, neck, and a portion of the under surface of the horizontal ramus posteriorly, otherwise the specimen is nearly entire, and in an excellent state of preservation.

The last molar is in position on either side, with their heels about five inches behind the anterior margin of the coronoid. They converge somewhat in front, the distance between them being 4·5 inches at the first ridge, 5 at the middle, and $10\frac{1}{4}$ at the heels, which are elevated above the margins of their sockets. Both molars have their hinder parts hidden in the jaw, but ten ridges are exposed, all of which are worn. Possibly the formula may have been from eleven to twelve plates with talons; assuredly not more, from the dimensions. The cement having been removed for a short distance down the external sides of the plates (Plate XXV, fig. 1), the ribbing of the plate has become exposed. It is the cross section, through detrition, of these elevated ridges which produces the false or faint crimping of the external border of the machærides, and distinguishes the character from plaiting or crimping, involving the entire thickness of the enamel. Unfortunately the crowns of the teeth are not worn even, and are here and there encrusted with the Iron Pan, which adheres most pertinaciously to the enamel. There is little of a trustworthy character to be learned from them further than, to all appearances, they are nearly, if not quite, entire. Such being the case, and judging from the exposed ridges, the dental formula does not at the furthest exceed *x* 14 *x*. Either tooth, as far as the callipers can extend and along the surface, evidently not the whole length, is $9\frac{1}{4} \times 3\frac{1}{4}$ inches. The cement is in excess, and the enamel, as usual, is thick with slight crimping along the external border.

It is to be regretted that the molars afford so little information. But the mandible is extremely interesting, as it is altogether different from any of the foregoing, and most certainly will not coincide with the descriptions given by Falconer of the mandible of *E. meridionalis*.[1] Indeed, without the molars the jaw is not distinguishable from that of the Mammoth, and, but for one or two characters, might belong to the thick-plated, and

[1] Op. cit., vol. ii, p. 140.

broad-crowned variety of *E. antiquus*. In fact, either the mandible is subject to great variability in the *E. meridionalis*, or else fig. 1 represents another species.

The following characters distinguish it from the preceding jaws, and are for the most part brought out in the figures in Plate XXV.

1. The diasteme is erect or nearly so, as in the Mammoth and *E. antiquus*.

2. The rostrum, instead of being part of the diasteme, projects from the symphysis like a nipple from a breast (Plate XXV, figs. 1 *a* and 1 *b*). These two characters are opposed to the diagnosis of Falconer, who states that the beak in *E. meridionalis* is a prolongation of the inferior margin, into which the diastemal ridges descend with great obliquity; but, considering the variability in this respect as regards the Mammoth shown in Woodcuts, figs. 19—21, page 138, it may be fairly doubted if any reliance should be placed on the projection in question, to which may be added the numbers or positions of the mental foramina.

3. The chin (Plate XXV, fig. 1 *b*) has the round character of that of the Mammoth, as shown in Woodcuts at page 135, figs. 4—12.

4. The length of the horizontal as compared with the width of the ascending ramus (Plate XXV) is also striking with reference to the other mandibles of *E. meridionalis* just described, and is in keeping with the jaw of *E. antiquus* and *E. primigenius*. How far, indeed, there are any characters of a constant and very reliable nature in connection with the lower jaws of these three species may be questionable from this instance of what is seemingly the mandible of *E. meridionalis*.

5. The great thickness of the ramus just behind the molar (Plate XXV, fig. 1) is assuredly greater in proportion in the jaw in question than I have seen in that of either of the other two species.

The measurements have been already recorded in the table, page 144; there are, however, a few additional measurements to be added as follow:

1. Height of coronoid and jaw, 13 inches.
2. Height of jaw in front of coronoid, 9 inches.
3. Thickness at the middle of the molar, 5·5 inches.
4. Thickness at the heel of the molar, 9 inches.
5. Antero-posterior length of symphysial gutter from the tip of the rostrum is 5·5 inches by callipers, and 8 inches by tape line.
6. Breadth of gutter in front below 2·5 inches, and 3·5 inches at its middle.
7. There are four mental foramina on the right, and only two on the left.

The British Museum contains an interesting cast (No. 3733) of a mandible from the Val d'Arno.[1] It is entire excepting the coronoids, and holds a fragment of the second, in front of an entire ultimate true molar, of which six discs only are invaded, whilst the

[1] Woodcuts of which are shown at p. 136, fig. 14, p. 139, fig. 28, and p. 142, fig. 40; its dimensions in the table at p. 144.

posterior portion is hidden in the jaw. The points of interest in this specimen and which correlate it with the preceding rami from East Anglia are:

1. The diasteme is somewhat more erect than in them,[1] but by no means so much as in the Mammoth, and the remarkable mandible from Cromer, just described (Pl. XXV). The diasteme runs into the beak,[2] which seems to have pointed downwards.

2. The horizontal ramus does not bulge out along its external border, especially at the base of the coronoid, as is the case in the Mammoth and *E. antiquus;* indeed, it repeats what I have just indicated of the preceding jaws from British strata, with the exception of Pl. XXV, fig. 1.

3. The condyles, which are rarely preserved in fossil Proboscidean remains, are present in this specimen, these with the contour of the neck are shown (p. 142, fig. 40).

4. The comparatively narrow neck, as seen from behind, and the disposition to compression of the longest sides of the oval condyle with the thicker end inwards, are features in accord rather with the African Elephant than the Mammoth and Asiatic; but the condyle is variable as to its contour in the Asiatic, and may have been so likewise in the extinct species. The dental canal is not well defined in the cast, but it seemingly is small, and directed upwards and backwards. The thickness of the jaw at the base of the coronoid is 7 inches, and the height at the commencement of the diasteme is 9 inches.

The width at the base of the coronoid is 20 inches, and between the condyles 15½ inches. The great breadth of the jaw at the latter is a character shown to be present also in *E. primigenius* and *E. antiquus.*[3]

The crowns of the molars have not been sufficiently impressed on the cast to afford any important data as to sculpturing. The space between them in front is 4 inches, at the middle 3 inches, and posteriorly 9 inches.

The ultimate molar of *E. meridionalis*, as met with in Northern Italy, is represented by the following data, recorded by Falconer:—Upper,[4] *x* 13 *x* in 11×4·3 inches; *x* 12—13 *x*. Lower, *x* 13 *x* in 10·25×3·3; *x* 15 *x* in 13×4·3 inches.

Such are the materials I have been enabled to study referring to the dentition of *E. meridionalis.* In considering the data by which Falconer established the specific characters of this Elephant, as met with in British strata, I have invariably compared the actual specimens, wherever available, with his lucid descriptions; and although I have seen cause to differ from him on certain structural conditions, yet considering the often fragmentary materials he had to deal with, it must be conceded that the differentiations he formulated are more or less confirmed by the preceding data.

[1] Fig. 14, p. 136, and fig. 28, p. 139.
[2] Fig. 14, p. 136; fig. 28, p. 139; fig. 40, p. 142.
[3] Page 140.
[4] Op. cit., vol. ii, p. 113.

Summary of the Dentition of E. meridionalis.

Incisors.—All the incisor teeth of *E. meridionalis*, hitherto discovered either in British strata or in Northern Italy, appear to differ from the ordinary typical tusk of the Mammoth in being relatively much stouter towards the proximal extremity, and by the absence of the spiral curvature so pronounced in the former. But individual exceptions might have occurred in a tooth so free to pursue an aberrant direction. Even, as has been already shown as regards *E. primigenius*, the upward tendency is not invariable in that species. The relationships between the tusk of *E. meridionalis* and that of *E. antiquus*, to which may be added the two recent species, in contour and direction are so close that, as far as specimens are concerned, it would be difficult to point out any reliable distinctions, excepting in size; moreover, examples of *E. antiquus* might be adduced equal even to the ponderous defensors of *E. meridionalis*.

The ante-penultimate milk-molar.—The very few instances of this member of the series show a tooth easily distinguishable from the same molar in the Mammoth and Asiatic Elephant, not, however, as regards dimensions so much as in thicker plates and more intervening cement. As regards *E. antiquus* and the African Elephant these distinctions are not so pronounced. The ridge formula in one tooth of *E. meridionalis* is *x* 3 *x* in 0·95 by 0·75 inch, thus fully bearing out characters confirmed by the true molars; but the exceptional instance of *x* 3 *x* in 0·7 inch shows considerable variability, whilst, on the other hand, such a first milk-molar as that of *E. antiquus* referrred to at p. 86, and shown on Pl. XII, fig. 3, embarrasses the diagnosis between their ante-penultimate milk-molars. Moreover, the crown patterns are usually not sufficiently developed to afford reliable data, so that one has to trust to the relative proportion of elements of the crown, which are also variable, as represented by the molars of *E. antiquus* and *E. primigenius* (Pls. I, VIII, IX, and XII). The first milk-tooth is therefore *per se* not reliable for diagnostic purposes.

Penultimate milk-molar.—The previous observations on this tooth, recorded at pp. 15 and 92, receive further confirmation from the more recent researches at p. 188. The sculpturing of the crown is often undistinguishable from that of large second milk-teeth of *E. antiquus*, showing, as in the Mammoth, crimping as well as channelling of the machærides. As regards the ridge formula I have not observed a tooth of a lower figure than *x* 6 *x*. The instance of "*x* 5 *x*," alluded to at p. 48, is a mistake on my part from a miscalculation of the ridges. With reference to dimensions, two entire upper molars range from 2·5 to 2·6 inches in length, and are 1·6 in breadth, whilst in five lower teeth the lengths vary from 2·6 to 3 inches, and the breadths from 1·2 to 1·5, three showing the latter measurement. It will be seen, however, that teeth of both *E. antiquus* and *E. primigenius* attain equal measurements.[1] However, a comparison of the crowns of penul-

[1] Pages 13 and 92.

timate milk-molars of the three species, as shown in Pl. I, fig. 3, Pl. V, fig. 2, Pl. XII, fig. 3, Pl. VI, fig. 2, Pl. X, fig. 3, and Pl. XXII, fig. 3 *a*, are in favour of that of *E. meridionalis* presenting in general a broader crown from the middle posteriorly than in the two other extinct Elephants.

Ultimate milk-molar.—Taking the British and Italian specimens recorded in the foregoing pages, this tooth appears to vary between seven and eight plates, besides talons. Out of eleven examples six show a ridge formula of *x* 8 *x* and five of *x* 7 *x*. The dimensions vary as follows:—In upper molars the length is from 4·4 inches to 4·6 inches, and the breadth from 1·4 to 2·5 inches; in the mandible these measurements are respectively 3·9 to 4·8 inches, and 1·7 to 2·8 inches in width. The general absence of crimping, the pronounced channelling, thick plates, abundant cement, the low height in proportion to breadth, so pronounced in true molars of *E. meridionalis*, are well shown in this member of the series. These are evident by comparing Pl. XVII, fig. 8, with the same tooth in *E. antiquus* and *E. primigenius* (Pl. I, fig. 4, Pl. XI, fig. 1 *a*, and Pl. XII, fig. 2), *erroneously* recorded in the explanation of the latter plate as a *pen*ultimate instead of an *ultimate* milk-molar.

First true molar.—Allowing for the difficulty always in discriminating between small-sized first true molars and the last of the milk series, I find that out of three upper and four lower entire teeth, the ridge formula varies from *x* 7 *x* to *x* 9 *x*. The majority show the figure of *x* 8 *x*. The maximum lengths are 7 inches, and the minimum 5·3 inches, whilst the breadths vary from 2 to 3 inches.

This tooth in general displays more distinctly-marked specific characters than the last milk-molar, especially in well-worn crowns, such as shown on Pl. XXII, fig. 1, which may be compared with Pl. III, fig. 2, of *E. antiquus*, and Pl. XI, fig. 2, and Pl. XXI, fig. 1, of *E. primigenius*.

Second true molar.—I have recorded seven entire molars belonging to this member of the series, viz. three upper and four lower. The ridge formula in the above varies from *x* 9 *x* to *x* 11 *x* in both jaws. The greatest length is 10 inches, and maximum breadth 4 inches, whilst the minimum length is 7·8 inches, and breadth 3·2 inches. Perhaps the majority of second true molars hold about nine plates exclusive of talons.

This tooth, always a valuable exponent of specific distinctions, is represented from British strata by several very characteristic fragmentary or entire specimens.

A comparison of Pl. XXIII, fig. 1, with the same molar of *E. antiquus* (Pl. II, fig. 1, and Pl. IV, fig. 2), shows the absence of crimping, greater breadth in proportion to length and height, and excess of cement, even as compared with the thick-plated variety of that species; whilst as regards *E. primigenius* (Pl. IX, fig. 1, and Pl. XII, fig. 1) these discrepancies are still more pronounced.

Ultimate true molar.—Among the numerous instances of this ponderous tooth met with on the Norfolk Coast, I find eight entire specimens, viz. two upper and six lower, from which the following data are determinable.

The extremes of the ridge formula are x 11 x and x 14 x. In one upper it is x 13 x, the other being x 14 x. In three lower, perhaps four, it is x 13 x, one has x 14 x and another x 11 x. Perhaps, as inferred by Falconer,[1] an additional ridge might be present; but the enormous dimensions attained by the larger specimens render it very improbable that the formula ever exceeded x 15 x. The longest molar of which I am cognizant is 13 inches in length, and the shortest, with the same formula, x 13 x, is 9·4 inches in length. As to width I find it ranges from 3 to 4 inches. It is true that the colossal teeth of *E. antiquus* (p. 173, Pl. XX, figs. 1 and 2), are much longer, but their plates are crowded together, and the lower molars taper very much posteriorly, which condition seems to be rare in *E. meridionalis*.

It is unnecessary to repeat the characters which distinguish the crown of the latter from that of the other two extinct species. The only molar with which one is likely to confound it is an unusually thick-plated crown of *E. antiquus*, but the expansion of its disc and the pronounced crimping (not, however, invariably present on every disc), together with a ridge formula not under x 15 x, will suffice to distinguish such a molar from that in question.[2] These comparisons are well shown in Pl. XXIV, figs. 1 and 2, as compared with the last molars of *E. antiquus* (Pl. V, fig. 1, Pl. IV, fig. 1, Pl. III, fig. 1, Pl. II, figs. 2 and 3, and Pl. XX, figs. 1 and 2) on the one hand, and of *E. primigenius* on the other (Pl. VIII, fig. 3, Pl. IX, fig. 2, Pl. XIII, figs. 1 and 1 *a*, and Pl. XIV, figs. 1, 2, and 3).

According to the foregoing data the ridge formula of the molar series of *E. meridionalis* will stand as follows:

Milk-Molars.			True Molars.		
I.	II.	III.	IV.	V.	VI.
$\frac{x\,3\,x\,—\,?}{x\,3\,x\,—\,?}$	$\frac{x\,6\,x\,—\,?}{x\,6\,x\,—\,?}$	$\frac{x\,8\,x\,—\,?}{x\,8\,x\,—\,?}$	$\frac{x\,8\,x\,—\,x\,9\,x}{x\,7\,x\,—\,x\,9\,x}$	$\frac{x\,9\,x\,—\,x\,11\,x}{x\,9\,x\,—\,x\,11\,x}$	$\frac{x\,13\,x\,—\,x\,14\,x}{x\,11\,x\,—\,x\,14\,x}$

These figures, with the exception of my error referred to in regard to the penultimate milk-molar, are substantially the same as were differentiated by Falconer from his researches, with additions consequent on discoveries made since his essays were written.[3]

As compared with *E. planifrons*, whose molars (of all the Sewalik species) come nearest to the above in regard to the dental elements and number of plates, the ridge formula, according to Falconer, is as follows:[4]

Milk-Molars.			True Molars.		
I.	II.	III.	IV.	V.	VI.
$\frac{x\,3\,x}{x\,3\,x}$	$\frac{x\,6\,x}{x\,6\,x}$	$\frac{x\,7\,x}{x\,7\,x}$	$\frac{x\,7\,x}{x\,7\,x}$	$\frac{x\,8\,x}{x\,8\,—\,x\,9\,x}$	$\frac{x\,10\,x}{x\,10\,x\,—\,x\,11\,x}$

[1] Op. cit., vol. ii, p. 118.

[2] Page 46.

[3] Op. cit., vol. ii, pp. 118 and 176.

[4] Op. cit., vol. ii, p. 91.

As compared with *E. insignis*, as far as known, and on the same authority—

Milk.			True.		
I.	II.	III.	IV.	V.	VI.
$\frac{x\,2\,x}{x\,2\,x}$	$\frac{x\,5\,x}{x\,5\,x}$	$\frac{x\,7\,x}{x\,7\,x}$	$\frac{x\,7\,x}{7\,x}$	$\frac{x\,8\,x}{x\,8-9\,x}$	$\frac{x\,10-11\,x}{x\,10-13\,x}$

V. OSTEOLOGY.

1. CRANIUM AND MANDIBLE.

The only portions of the skull of *E. meridionalis* hitherto derived from British strata are the fragments of upper and lower jaws just described. The highly suggestive skulls in the Museum of the Piti Palace, Florence, from the Valley of the Arno, furnish very conclusive evidence in connection with the osteological characters of this Elephant, and have been for the most part described by Nesti and Falconer.[1] Having inspected these remains, and compared them with the same parts of other extinct European species, I can endorse the views advanced by Falconer in his excellent descriptions.

As far as the skulls of *E. meridionalis*, *E. antiquus*, and *E. primigenius* are concerned, the lengthened comparisons given at page 128 need not be repeated. These, however, may be briefly summarised as follows:

1. The skull of the Meridional Elephant, from the vertex to the nasal aperture, is relatively shorter than those of the Mammoth and Asiatic Elephant, approaching nearer to that of the African and the short-crowned cranium of *E. planifrons* and other Sewalik species. Unfortunately no skull of *E. antiquus* is available.

2. The posterior border of the vertex is transverse and rounded in the Meridional, although not to the extent apparent in the crown of the African skull; whilst in the Mammoth and Asiatic Elephant it is narrower, and rising higher gives the prominence to the skull which distinguishes at a glance the crania of the two latter from the African.

3. As in all Elephants with ponderous incisors, the premaxillaries are long and broad; and the frontal depression of the Asiatic and Mammoth is more or less apparent also in the Meridional, whereas the same part is flat in the African.

4. The spaces between the temporal fossæ is narrower than in the Asiatic and Mammoth Elephants, contrasting with the relative greater dimensions in the African and *E. planifrons*.

5. The nasal aperture is nearer to the vertex than in the Asiatic and Mammoth, in consequence of the lowness of the crown.

[1] 'Nuova Giornale de Liter.,' 1825, and 'Pal. Mem.,' vol. ii, p. 121.

6. The incisive alveoli are nearly parallel; whilst they diverge considerably in the Mammoth and Asiatic, as seen in Woodcuts, figs. 1, 2, and 3, pages 130 and 131.

7. The lachrymal tubercle is pointed in *E. meridionalis*, and more prominent than in the Mammoth.

8. The zygoma is much below the level of the condyles in the Meridional, as obtains in the African and in the short-crowned fossil Elephants of Northern India, to wit, *E. Namadicus*, *E. planifrons*, &c.; moreover, it inclines to the molars at an angle of 35°, whilst it is nearly parallel to them in the Mammoth and Asiatic Elephant.

In fine, taken with all these and other, but minor, particulars, the skull of the Meridional is broadly distinct from that of the Mammoth and Asiatic Elephant. It is allied to the African, but more so to the other short-crowned species of the Sewalik deposits, with which careful comparisons may establish still closer relationships. To what extent these well-marked distinctions would compare with the skull of *E. antiquus* I am unable to state.

2. CERVICAL VERTEBRÆ.

Atlas.

Numerous entire specimens of this bone are preserved in the British Museum and Norwich Collections.

No. 36,436, B. M., an anterior view of which is shown in Plate XVII, fig. 3, was dredged off the coast of Essex, opposite Clacton. The transverse processes are injured. Here the odontoid cavity, as formerly pointed out, is much higher than broad as compared with the same in *E. primigenius* and *E. antiquus*, and the upper surface of the arch is curved instead of being flat in them (figs. 1 and 2). It is evidently, however, subject to individual differences, as shown by Davies in the case of the latter species.[1] The above atlas is rivalled by another colossal specimen, also from the Norfolk coast, in the possession of R. Johnson, Esq., of Palling, Norfolk. The dimensions, as compared with the huge bone of *E. meridionalis* from Tuscany, figured by Cuvier in the 'Ossemen. Fossil.,' pl. xvii, figs. 3 and 4,[2] are as follows:

Maximum breadth, 18·5, against the Tuscan, which is 19·2 inches.

„ height, 10·5 ditto 9·3 „

Vertebral and odontoid canals, 5×4, against the Tuscan, which is 3·6×4·5 inches.

The anterior condyloid articulations in Mr. Johnson's specimen are each 6×4·5 inches by tape along their curves. The foramen for the first cervical nerve is very large, and exposed in all, being 1·8×1·3 inches in breadth.

[1] 'Cat. Brady Collection,' p. 16.

[2] This atlas is also figured by De Blainville, 'Osteographie,' pl. iv.

The general outlines of the condyloid cups will be seen to vary in the three species. They are oval in the Mammoth (fig. 1), more rounded in *E. antiquus* (fig. 2) externally, and less circular in *E. meridionalis* (fig. 3); but the excessive height as compared with the width, so pronounced in the latter specimen, is not the case in the huge atlas from Tuscany, which assimilates best in the relative dimensions of the canal and the condyloid surfaces to the same parts in fig. 2 of *E. antiquus;* the upper surface of the arch, however, is not so flat as in the latter, and assimilates to the Clacton bone in that particular.

Axis.

The vertebral canal in the two recent Elephants differs somewhat. In the Asiatic the opening is larger in the vertical, as compared with the transverse diameter, than in the African. In these respects the Mammoth (Pl. XVII, fig. 6) agrees with the former, whilst that of *E. meridionalis* (fig. 4) is decidedly like that of the latter. Unfortunately the axis of *E. antiquus* (fig. 5) has lost the greater portion of the arch, but it seems to have been very broad, like that of the two last-named species; its anterior articular surfaces are subtriangular, and outer margins projecting with the odontoid process excentral and close to the dorsal border of the centrum.

The huge axis, No. 27,872, B. M. (fig. 4), like the atlas (fig. 3), was dredged off Clacton, Essex, and, as far as the articulating surfaces are concerned, might have belonged to the same individual.[1]

Several of the other cervical vertebræ in the Norwich Museum, and in Mr. R. Johnson's Collection from the Norfolk coast, indicate the enormous dimensions of the animals. They show, however, no diagnostic characters as compared with other species.

An enormous and nearly entire bone, possibly the third cervical, in Mr. R. Johnson's Collection, affords the following measurements:

Entire height 8 inches.

Height of centrum 5·5 × 8·5 inches.

Breadth of circular neural canal 5· inches.

Thickness of the centrum 4· inches.

Another, possibly also a third cervical, has a centrum 7·5 × 8·5 inches in breadth, and is 3·4 inches in thickness.

3. DORSO-LUMBAR VERTEBRÆ.

As far as the other bones of the spinal column are concerned, there is not much to observe of importance beyond size.

[1] Nesti, 'Nuov. Giorn. de Liter.,' No. 24, p. 194, gives the dimensions of an axis from the Val d'Arno as follows:—Height 0·325; breadth of centrum 0·268; anterior articular facet 0·162 × 0·107 mètre.

A centrum of a first dorsal in the above gentleman's possession is $7{\cdot}4 \times 10{\cdot}4$ inches in the transverse direction, and is 3·5 inches in thickness.

There is a large second dorsal, No. 27,878, B. M., covered with barnacles and shells of *Serpulæ*, dredged off Clacton, Essex.

The tip of the spine is lost, otherwise the bone is entire. It is 22 inches in height, with a maximum breadth of 13 inches. The centrum is 2·2 inches in thickness, and 5·4 in height, by 6·5 in breadth. The vertebral canal is nearly an equilateral triangle, being 2·7 in height, by 2·8 inches at the base.

Other two specimens, one a first dorsal, the other from about the middle of the series, are in the above collection from the same locality. It is just possible, however, that both may belong to *E. antiquus*. The first dorsal has a neural canal $3{\cdot}6 \times 2{\cdot}8$ inches in breadth; the centrum is 5 inches in height and 6 inches broad. The height of spine and neural canal is 14 inches, and thickness 2·4 inches. The middle dorsal shows a less triangular canal, and is $2{\cdot}5 \times 2{\cdot}8$ in breadth, with a centrum 5 inches in height by 6 in breadth. The height, including spine, from the centrum, is 16·5, and thickness of the latter 2·4 inches.

The fragments of Ribs and portions of Sterna in collections are not sufficiently entire for comparative purposes.

4. PELVIC GIRDLE.

The huge pelvic bones from the Norfolk Coast have been already referred to at page 151, in connection with the elements of the pelvis of the Mammoth, with which they agree in general characters but differ remarkably as regards dimensions. At the same time, until similar parts in *E. antiquus* have been described, it seems uncertain whether these huge bones belong to its skeleton or to that of the species under consideration.

5. SHOULDER GIRDLE.

Scapula.

Remains of huge shoulder-blades are represented by several specimens in the Norwich and British Museums, but, with the exception of the glenoid cavity, few other points admit of comparison being made between them and the scapulæ described at page 145. The following table will suffice to show the dimensions attained by the Elephants from the Forest Bed and other deposits along the East Coast of England.

	No. 275, Gunn Collection, Norwich Museum, Pl. xviii, fig. 3 (*E. meridionalis ?*).	Norwich Museum (*E. meridionalis ?*).	Norwich Museum (*E. meridionalis ?*).	273, Gunn Collection, Norwich Museum (*E. meridionalis ?*).	Norwich Museum (*E. meridionalis ?*).	274, Gunn Collection (*E. primigenius ?*).	271, Gunn Collection (*E. primigenius ?*), Pl. xxii, fig. 4.
Height of glenoid cavity[1]	11·5	11	11	11	11	7·5	8·5
Maximum breadth of glenoid cavity	6	6	6	5.5	6	4	4·5
Antero-posterior diameter of neck	12·5	13·8	13	11·5	12·5	9	10
Distance of base of spine from margin of the glenoid cavity	6	6·5	5	4	6	(Lost)	4

In comparison with the Mammoth, it appears that the glenoid cavity is not so compressed laterally and is broader inferiorly in the larger scapula, as shown in Plate XVIII, fig. 3, as opposed to the same parts in the Mammoth (Plate XXII, fig. 4, and Plate XV, fig. 1). The neck, too, is relatively broader in the former.

With reference to the localities where the fragments quoted in the Table were found, No. 271 (Plate XXII, fig. 4) is a left scapula of the Mammoth in the Gunn Collection. It was dredged off Yarmouth near Kessingland, but only a fragment of the blade, neck, and glenoid cavity is preserved. No. 275 seems to have been dug out of the Forest Bed, as portions of the matrix still adhere to the bone. The second in the Table has a label attached, stating that it was "found at Mundesley, after 'a great run' on the top of the Forest Bed, consisting of nodules of blue clay mixed with red, gravelly pan, and close to a jaw of *Trogontherium*." In the British Museum there is a portion of a glenoid cavity, the maximum width of which is 5·5 inches, and another entire articular surface; both are from Happisborough on the Norfolk coast. The height of the articular surface of the latter is 9 inches by callipers, and 10 inches by tape along the curves of the cavity; width, 4 inches above, 4·5 at the middle, and 4·6 inches below.

6. HUMERUS.

The colossal dimensions of the Elephantine remains met with in the fluviomarine and freshwater deposits of Norfolk and Suffolk coasts receive ample confirmation from the

[1] Nesti gives the following dimensions of the glenoid cavity of a scapula from Val d'Arno :—Height 0·291 mètre, maximum breadth 0·170 (11·5 by 6·6 inches), breadth of neck 0·380 mètre = 15·0 inches. The entire length of this scapula was 1·080 m., and spine, ·900 m. 'Nuovo Giorn. de Literat.,' No. 24, p. 194.

appendicular as well as the axial elements of skeletons. Taking the complete skeleton of the famous "Choonee" of India in the Museum of the Royal College of Surgeons of England as a standard of the Asiatic Elephant, we find its humerus is 35 inches in length and the height of the skeleton at the commencement of the dorsal region is 103 inches. The huge humerus in Miss A. Gurney's Collection in the Norwich Museum has a maximum length of 53 inches. This specimen, as compared with the above, would give a height of 156 inches or 13 feet, being one foot over that of the largest recorded recent African Elephant, which rarely attains the maximum height of 12 feet at the withers.

Before proceeding to the consideration of the characters of the humerus inferred to belong to *E. meridionalis*, it will be necessary to refer to the humerus of *E. antiquus* as recorded at page 57. In addition to the data there given, I have acquired the following further evidences since the publication of my memoir.

In a valuable collection of Mammalian remains from Ilford, recently bequeathed to the Jermyn Street Museum by the late Dr. Cotton, are numerous teeth and bones of *E. primigenius* and several relics of *E. antiquus*.

The superb humerus, No. 18, represented on Plate XVI, fig. 6, has lost the greater part of the large tuberosity, and the head is slightly injured, but otherwise it is entire. The dimensions are given in the Table opposite. The noteworthy points in comparison with the humeri of other species may be indicated as follows:

1. The supinator ridge descends more perpendicularly from the shaft (fig. 6 *a*), and is more horizontal towards its apex (fig. 6), than in any of the other species; the nearest approach to it seen is the humerus of *E. meridionalis* (fig. 2).

2. The internal condyloid ridge (fig. 6 *a*), in proportion to the size of the bone, is narrower than in the Mammoth (fig. 1 *a*) and *E. meridionalis* (fig. 2 *a*), but not more so than in the *E. Asiaticus* (fig. 4 *a*).

3. The contours of the external and internal articular surfaces of the condyles (fig. 6 *b*) show more expansive surfaces than in any of the allied species, especially *E. meridionalis* (fig. 3). The concavity of the inferior border of the articular surface (fig. 6 *b*) is deeper and more central than in the other two extinct Elephants and the recent species, whilst the trochlear depression is more circular than in them.

In all these characters the above humerus agrees with the specimens already described at p. 58 and referred to *E. antiquus*, and with which, I think, it may be fairly included.

The following Table represents the dimensions of the humerus in full-grown individuals of the recent and certain extinct Elephants.

	Entire length.	Smallest girth.	Girth proximal extremity.	Girth distal extremity.	Width distal articular surface.	Dimensions of articular surface of head (by tape).
No. 2744, R. C. S. E., *E. Asiaticus*, Pl. XVI, fig. 4...	36·5	16·5	33·5	27	8·5	7·5 × 7
708H, B. M., *E. Africanus*, Pl. XVI, fig. 5	35·5	13·1	29·5	24	7·8	7·9 × 7
23,151, B. M., *E. antiquus*.....	41	22·5	Lost	?	?	13 × 10·5
18, Cotton Collection, *E. antiquus*, Pl. XVI, fig. 6 ...	41·4	17½	...	32	8·5	10 × 7·8
36,700, B. M., *E. Namadicus*.....	47	?	45	?	?	
30,531, B. M., *E. primigenius*, Pl. XVI, fig. 1.....	34	13·5	...	25·5	8	9 × 6
$\frac{C}{128}$, B. M., Brady Collection, *E. primigenius*	28·7	11·8	27·8	20·5	6·5	9 × 5
200, Gunn Collection, Norwich Museum, *E. meridionalis*, Pl. XVI, fig. 2[1]	51	22	45	40	11·5	15 × 9·5
Miss A. Gurney's Collection, Norwich Museum.....	53	26·6	39	...	13	15 × 10·5
Norwich Museum, *E. meridionalis*	...	...	...	...	...	
Norwich Museum, *E. meridionalis*, Pl. XVI, fig. 3[2]...	...	...	45	37	10	13·5 × 12
B. M., Val d'Arno; 'Pal. Mem.,' vol. ii, p. 143	47	...	...	32	13	

With reference to *E. meridionalis*, there are other portions of articular surfaces and pieces of shafts in the Norwich Museum, and in several private collections, representing fully as large, if not larger, colossal Elephants than the foregoing. The distal end of an enormous arm-bone, No. 33,396, B. M., from Happisborough, Norfolk coast, has a breadth of articular surface of 11 inches. Notably, the inner condyle is proportionally larger than in *E. primigenius* and the humerus in the Cotton Collection. The ginglymus is 6 inches in thickness, and 11½ by tape in the antero-posterior direction; and the inner condyle, by the same appliance, furnishes an antero-posterior length of 16·5 inches against 14·5 of the outer condyle.

One point is very striking in the majority of these enormous bones in comparison with humeri of very old individuals of, at all events, the Mammoth and recent species, that is, the general absence of pronounced ridges, in place of which there is a general smoothness of the surface, as seen in bones of adolescent animals, whilst the epiphyses, which are the last to become anchylosed, are all firmly united. The absence of prominent ridges might tend to the belief that these colossal Proboscideans were tardy in their movements and seldom given to active muscular exertion.

Referring to Pl. XVI, the more distinctive characters of the humerus of the *E. meridionalis* (figs. 2 and 3), as compared with the two extinct and the two recent species, appear to me as follows:

1. It is stouter than that of *E. antiquus*, and rather more so than in *E. primigenius*, and much more so than in either of the recent Elephants.

[1] The external condyle by tape in the antero-posterior measurement is 12½ inches, and the internal 13½ inches; the width of the bicipital groove is 2¼ inches.

[2] The antero-posterior measurement by tape of the outer condyle is 9 inches, and the inner 10½ inches, and of the central portion of the ginglymus 9½ inches.

2. The supinator ridge (fig. 2) is shorter and more horizontal than in any of them.

3. The upward continuation of the supinator ridge (fig. 2 *a*) is not nearly so well defined as in them.

4. The contour of the distal articular surface (fig. 2 *a*) is more like that of the Mammoth (fig. 1 *a*) than *E. antiquus* (fig. 6 *a*) and the recent species (figs. 4 and 5). This refers to the configurations of the condyles, the arc on the lower border, and trochlear depression.

5. The internal condyloid ridge is broader (fig. 2) than in any of the above.

6. The deltoid ridge (fig. 2) is not so prominent as in *E. primigenius* and *E. Asiaticus*, and is more in keeping with *E. antiquus* and *E. Africanus*.

Taken collectively, as far as materials enable me to determine, the comparisons already instituted in connection with the humerus in the three extinct and the two living species seem to furnish the following contrasts as regards the former:

1. The bicipital groove is much the same in all the extinct British Elephants.

2. The contour of the head is more circular, and it is less compressed in *E. meridionalis* than, at all events, in the Mammoth.

3. The supinator ridge is shorter, and is the least salient in *E. meridionalis*.

4. The deltoid ridge is prominent in *E. primigenius*, and not nearly so pronounced in the other two.

5. The hollow in front of the supinator ridge is not so deep in *E. primigenius* as in the other two.

6. The trochlear depression is deeper in *E. antiquus* than in the others.

7. The margins of the cubital articular surfaces are not so sharp and defined in *E. meridionalis* as in *E. primigenius* and *E. antiquus*.

8. The contour of the lower border of the cubital articular surface is more central in *E. antiquus* than in the other species.

9. The internal condyloid ridge is broader in *E. meridionalis* than in the other two.

10. The outer condyle is more globose in *E. antiquus* than in either of the two other species.

11. The humerus relatively is not so stout in the *E. antiquus* as in the other two.

7. CUBITUS.

The relations of the two elements of the forearm, to wit, the amount of obliquity of the radius in *E. meridionalis*, as compared with other species, remain to be shown when specimens turn up. At present I have not seen the entire bones of the same individual *in situ*.

Ulna.

The large ulnæ from the East Coast, like the arm-bones, present few prominent ridges for the fasciæ and muscular attachments, as compared with the gnarled humeri and ulnæ

of old individuals of the Mammoth. The radial pit is more open and shallow than in the Mammoth, and the shaft is not so flattened nor are the ridges posteriorly so strongly pronounced. The aspects of proximal and distal articulations furnish apparently no characters of importance.

The fragment of the distal extremity, No. 246 of the Gunn Collection, from the "Iron Pan of the Forest Bed," shows a less perpendicular radial facet than I have seen in the Mammoth, but there appears some individual variation in specimens, rendering this character of little value. The dimensions of its carpal articulation is 5·5 inches in the antero-posterior (by tape along the surface), and 7 inches in the transverse diameter.

A proximal fragment, including a little more than half the shaft, in the same Collection, shows a girth of midshaft of 17 inches, and a conjoint breadth[1] of the proximal articular surfaces of 11 inches. Another fragment of the proximal extremity, No. 33,395, B. M., from the East Coast, shows a wide and gaping radial pit. But no entire ulna from the above situation has come under my notice.

Radius

An entire radius of a colossal-sized Elephant, in the possession of Mr. R. Johnson, of Palling, near Stalham, Norfolk, was found at Mundesley, on the coast, along with the humerus (Pl. XVI, fig. 2) and the enormous femur described at page 222. Mr. Johnson was good enough to permit me to take a few measurements of the above and other bones in his collection. With reference to this radius I have taken the following measurements:

Length 39 inches.[2]

Girth, midshaft, 10·4 inches.

Girth, proximal end, 16 inches.

Girth, distal end, 25 inches.

Distal articular surface 9 in the a. p. d. by 6 inches in the transverse.

Proximal articular surface $5\frac{1}{4}$ by 3·5 inches in the antero-posterior diameter.

The anterior surface of the shaft, as before noticed,[3] is round and prominent down to about the middle third. The outer and inner sides seem flattened as far as a thick coat of matrix would permit inspection. The shape is tectiform, with rather abrupt slopes.

[1] Both Cuvier ('Oss. Foss.,' figs. 15, 16, and 17) and De Blainville ('Osteog.,' pl. v) notice large fossil ulnæ, neither of which specimens from their dimensions appear to belong to the Mammoth. The former authority shows that, excepting being a stouter bone, it shows no character distinct from the Indian Elephant. The radial pit, however, is much narrower than in the Pl. XVIII, fig. 1 *a*. Their lengths are 0·825 and 0·832 mètre respectively. De Blainville's specimen, however, has the distal articulation wanting. Nesti (op. cit.) gives the length of an Italian specimen 0·840 mètre.

[2] Nesti records an instance of a radius of *E. meridionalis* as 0·752 m. in length by 0·141 m. in breadth. 'Nuov. Giorn. de Literat.,' No. 24, p. 194.

[3] Page 158.

8. CARPUS.

Scaphoid.—I have already referred to this bone as met with in the Forest Bed, in comparison with that of the Mammoth.[1] The specimen alluded to is of colossal dimensions, and No. 150 of the Gunn Collection.

The following are its characters:

Extreme length	7 inches.
„ breadth	6 „
Radial facet	3 × 2·5 inches.
Trapezoidal facet	4·5 (a. p. d.) × 2·2 inches.
Upper lunare facet	2·5 × 1· „
Lower „	1·8 × 1·4 „

There is no facet for the trapezium.

The radial facet is nearly erect, as in the Mammoth.

The trapezoidal and magnal facets are continuous, the former is nearly flat with the latter rising gradually upwards from it, as in the African Elephant.[2]

Lunare.—One of the largest lunares I have seen from the East Coast is No. 155 of the Gunn Collection. It is covered with barnacles, and is in all probability either a a dredged or a beach specimen.

The length is $7\frac{1}{4}$,[3] and maximum breadth 7 inches.

The radial facet is $5\frac{3}{4}$ by $5\frac{1}{2}$ inches.

The magnal facet 6 by 6, and maximum thickness $4\frac{1}{2}$ inches.

The characters of the above specimen, as compared with the same parts in the Mammoth, have been already recorded at page 159 along with other large lunares, to wit, the obliquity of the ulnar facet, the slight concavity of the radial aspect, absence of scaphoidal attachments—not uncommon in similar bones of large individuals of both the Mammoth and Asiatic forms—a deep concavity of the marginal surface, especially towards its extremity, from whence it rises up into a plateau on the further extremity of this articular surface. The presence, however, of scaphoidal facets is shown in No. 151 of the Gunn Collection. It does not display so pronounced flattening and concavity of the magnal aspect, otherwise it is of about the same dimensions as the preceding.

In a specimen in the King Collection, Museum of Practical Geology, Jermyn Street, also from the East Coast deposits, the same measurements give a length of $6\frac{1}{2}$ by 6 inches in the transverse diameter, the radial facet is $5 \times 5\frac{1}{4}$ inches. The magnal facet shows a deep pit in the same position as in the last, and is $5\frac{3}{4}$ by 6 inches; the thickness $4\frac{1}{2}$ inches.

[1] Page 159.

[2] A shorter scaphoid is recorded by Nesti from the Val d'Arno. Its length is 0·165 mètre, and maximum breadth 0·140 mètre.

[3] Nesti gives a lunare not so large from Northern Italy. It is 0·158 mètre in length.

A still smaller bone, No. 33,415, B. M., from the East Coast, is $6 \times 5{\cdot}8$ in breadth, and 3·5 inches in thickness. The characters are not quite so much pronounced, but indeed the lunare furnishes little of a reliable character for diagnostic purposes, and like many of the other bones can only be doubtfully referred to *E. meridionalis*.

Cuneiforme.—The largest specimen from the Norfolk Coast I have seen, and certainly of colossal dimensions, is No. 156 of the Gunn Collection. The following are its dimensions:

Length 10 inches.[1]

Maximum breadth 6 inches.

Ulnar aspect 4 (a. p. d.) by $6\frac{3}{4}$ inches.

Unciform aspect 6×7 inches.

Thickness 4 inches.

The lunare facets are well developed.

No. 159 of the above Collection, from the same locality, is $7\frac{1}{4} \times 6$ inches. Ulnar facet $4 \times 5\frac{3}{4}$, and the unciform 6×5 inches; thickness $3\frac{1}{2}$ inches. Here the lunare facets are also well developed, and the pisiform facet is quite erect and triangular.

A smaller bone, No. 63 of Mr. Savin's Collection, found at Overstrand, Cromer, is $7 \times 5\frac{1}{2}$; ulnar facet $4 \times 5\frac{1}{2}$; thickness 3 inches.

These cuneiformes have been already referred to[2] in comparison with similar bones of the Mammoth. They show no very distinct characters from the latter, but differ from the African species.

With reference to *E. antiquus*, it will be seen that the admeasurements of this bone[3] rival the largest of the above specimens, otherwise I can see no characters sufficient to separate them.

The *pisiforme* is not represented in any collections examined by me.

Trapezium.—The specimen, No. 33,418, B. M., from East Anglia (Pl. XIX, fig. 10), has been already described[4] in connection with what appears to be the equivalent bones in *E. primigenius* and *E. antiquus* (figs. 8 and 9).[5]

The differences between the three seem pronounced; and, unless subject to variability, this element is diagnostic of the three species.

Trapezoidale.—This bone, referred to[6] in connection with the Mammoth, is represented

[1] Nesti records an Italian cuneiforme of much smaller length, and somewhat greater width, being 0·158 by 0·155 m. in width.

[2] Page 160.

[3] Page 60.

[4] Page 161.

[5] None of these seemingly, as regards size, can compare with this bone in the *E. meridionalis* of Northern Italy. Nesti, 'Nuov. Giorn. de Literat.,' No. 24, p. 194, assigns a length of 0·240 m. or 9·4 inches to one specimen.

[6] Page 161.

by No. 160 of the Gunn Collection, Norwich Museum. It is from the Forest-Bed Series, and measures 5 × 2·8 inches.[1] Its scaphoidal surface is 4·8 inches in length, and trapezial 2 × 2·4 inches. In comparison with the foregoing bones of *E. primigenius* and *E. antiquus*, it assimilates more closely to the broad surface of the latter than to that of the former.

Magnum.—The dimensions of this bone in the foot, which I have referred to *E. antiquus*,[2] exceeds the dimensions of the largest specimen I have seen from the East Coast, and another, No. 18,244, B. M., from Grays, Essex, in all probability also belongs to *E. antiquus*. The latter is shown in pl. li, fig. 6, of the 'Fauna Antiqua Sivalensis,' and is 6·4 × 5·8 inches in width. It is undistinguishable from the former in size and characters. Nor does it appear that, unless in rather smaller dimensions, the following from the East Coast differ from them, unless in minor points, namely, No. 33,410, B. M., which has the convexities and concavities of the articular surfaces less pronounced, and the metacarpal surface not so broad in proportion.

The dimensions of this specimen from Happisborough, Norfolk, are—

Maximum (a. p. d.) 6·8 inches.[2]

Breadth[3] 5·0 ,,

Thickness 5·8 ,,

A large magnum, scarcely referable to *E. primigenius* on account of size, is shown by No. 164, Gunn Collection. It was dredged off Yarmouth, Norfolk. Its

Length is 6 inches.

Breadth 4·5 ,,

Facets for the three metacarpals 4·5 × 2·4 and 4·5 × 1 inches.

Unciform aspect 5 × 2·5 inches.

Height of the specimen is 5·5 inches.

Unciforme.—This bone in the foot of *E. antiquus*, previously noticed,[4] rivals in size many of the huge bones from the East Coast.

No. 33,107, B. M., from the Norfolk Coast, has an antero-posterior and transverse diameter of 7 inches, and is 6 inches in thickness.

No. 172, Gunn Collection, from the Forest Bed, gives the following dimensions:

	E. meridionalis.		*E. antiquus.*	
Maximum length	6·5	inches.	6·8	inches.
Breadth	7	,,	7·9	,,
Cuneiform facet	5·2 × 5·2	,,	5·8 × 4·8	,,

[1] Nesti gives a larger specimen from Northern Italy. It is 0·146 × 0·125 m. or 5·7 × 4·8 inches.

[2] Page 60.

[3] Nesti gives one which is 0·160 × 0·120. I have found considerable discrepancies individually in these two dimensions in various species (see "Dentition and Osteology of the Maltese Fossil Elephants," 'Trans. Zool. Soc.,' vol. vi, p. 72).

[4] Page 60.

	E. meridionalis.	*E. antiquus.*
Third metacarpal facet	5 ×2·1 inches.	3×1 inches.
Fourth „ „	4·4×4 „	7×4 „
Fifth „ „	4 ×3 „	
Magnal facet	5 ×3·5 „	
Maximum height	5·6 „	6 „

The above contrasts with the same parts of *E. antiquus*, recorded at p. 60. The discrepancies, however, may be the result of specific or individual character, but certainly the relative sizes of the surfaces for the third metacarpal are remarkable.

9. METACARPUS.

The characters of the metacarpals met with on the East Coast, when compared with equivalent bones of the recent species and those of *E. primigenius* and *E. antiquus*, show little that is noteworthy, excepting, perhaps, in the proximal extremities of the third digit, as shown in Pl. XVIII, fig. 5. They, moreover, seem to differ considerably individually in their contours, especially of the two outer toes.

The following are a few of the characters and dimensions of the more characteristic specimens:

A *first* digit from Overstrand, Cromer, in Mr. Savin's possession, is 5 inches in length. The proximal facet is 3×2, and distal 5 inches (by tape) ×2·5 inches; the girth, midshaft, is 8·4 inches. This specimen does not appear to differ from the equivalent bone in the African Elephant, as has been indicated.[1]

Third digit.—The specimen (Pl. XVIII, fig. 5) has been referred to;[2] it is from Happisborough. In this metacarpal (No. 33,428, B. M.) the magnal facet for the fourth metacarpal is not nearly so broad as in *E. antiquus*.

This very large bone is 10·8 inches in length, the height of the proximal extremity being 6 inches, and smallest girth of shaft 11·8 inches. The upper portion of the magnal facet is more concave than in the bone attributed to *E. antiquus*—a character I have observed in all the large third metacarpals from the East Coast.

Another specimen in the Gunn Collection is 8·5 inches in length; the breadth of the outer proximal facet for the fourth metacarpal and unciform is 4×3·5 inches; the antero-posterior length of the distal articular surface (by tape) is 5·5×3·8 inches. It displays the same characters of the proximal articular surface as in the former.

Fourth digit.—A metacarpal in the Norwich Museum is 7·5 in length, with an unciform facet of 4×3·5 inches. The surface for the third metacarpal is 3·5×1·4 inches, whilst that for the fifth metacarpal is 4·5×1·8 inches. The distal (a. p. d. by tape) is 5·5 inches, and transverse 2·8 inches. The girth, midshaft, is 10 inches.

[1] Page 162. [2] Page 163.

Another specimen, also in the Gunn Collection, and from the Forest Bed, is 7 inches in length. The unciform surface is 3·5 in height by 2·8 inches in width; the third metacarpal facet is 2·8 × 1·4 inches.

Distal end 5·8 × 3 inches.

Girth, midshaft, 11 inches.

Fifth digit (Pl. XVIII, figs. 8 and 8 *a*), No. 33,433, B. M., is from Happisborough. It is 7 × 5·2 inches.

As indicated with reference to the Mammoth, the unciform facet (fig. 8 *a*) is much more ovate; otherwise I cannot perceive any peculiarity worth recording.

10. PHALANGES

Are not uncommon in collections, but do not present, excepting in their large dimensions, any points different from the equivalent elements of the feet of allied species.

A first phalanx of possibly the second digit, from Overstrand, Cromer, in Mr. Savin's Collection, is 5 inches in length, with a girth at the middle of 8·4 inches. The proximal articular surface is 3 × 2·5 inches, and the distal 5 × 2·5 inches.

11. FEMUR.

Comparisons between this bone and that of the Mammoth have been already furnished.[1]

As compared with any femur at all referable to European extinct Elephants, the specimen in the possession of Mr. Randall Johnson, of Palling, far outstrips the largest in dimensions. It was discovered at Mundesley, in the Forest Bed, in conjunction with the humerus, No. 200 of the Gunn Collection (Pl. XVI, fig. 2), and the huge radius also referred to.[2] Conjointly they represent a stupendous Elephant only second to the Dinotherium in size. I regret being unable to furnish a representation of this huge thigh-bone. I was fortunate, however, through the kindness of Mr. Johnson, in being permitted to take the following measurements during a hurried survey of his valuable Collection at Stalham, in the company of my friend, Mr. Gunn.

The specimen is in a perfect state of preservation, without seemingly a chip throughout its vast surface.

The total length is 60 inches.[3]

Breadth of proximal end at the great trochanter 19 inches.

[1] Page 164. [2] Page 217.

[3] The famous Eppelsheim specimen of the Dinotherium had a femur of 62·7 inches in length.

Girth, midshaft, $20\frac{1}{4}$ inches.

Breadth across both condyles 12 inches.

Antero-posterior diameter of the outer condyle along the curve, by tape 20, and by callipers 11 inches.

Antero-posterior diameter, by tape, along the curve of the inner condyle 21 inches.

The condyles coalesce more than in the Mammoth, and leave a narrow fissure.[1] The outer condyle is like the African, being more globose than in the Mammoth.

Mr. Johnson possesses, likewise, the distal extremity of another huge femur from Palling. The antero-posterior diameter of the outer condyle is 17·5 inches, and the inner (both measured along the curve by tape) is 18 inches. The maximum breadth of the intervening sulcus posteriorly is 5·5 inches, and the linear measurement across both condyles 9·5 inches.

Here the intercondyloid space is very *narrow*, as in the Mammoth, and there is considerable bending inwards of the condyles, more so than I have seen in the femur of any other European or fossil Elephant, or, indeed, in either of the recent species.

Another entire femur (Pl. XXVI, figs. 3, 3 *a*, and 3 *b*)[2] was lately discovered by Mr. Savin, at Overstrand, near Cromer, and is now in the possession of Mr. J. Backhouse, West Bank, York, to whom I am under obligations for two excellent photographs of the specimen, and the following data in regard to its dimensions. The bone is nearly entire, excepting the head and neck, which are fractured. This and Mr. Johnson's specimen appear to have belonged to individuals which had perished, like the Irish Elk, by being either mired or drowned, their carcases, in the latter case, floating down a river, and the remains deposited in an estuary or delta.

The total length is $49\frac{3}{4}$ inches; girth (by tape) at midshaft 18 inches. Breadth at the great trochanter is 14 inches; girth of ditto 36 inches; girth of ball 22 inches. Maximum girth of distal articulation 34 inches. Maximum breadth across the condyles (linear) $10\frac{1}{2}$ inches. Antero-posterior measurement of the inner condyle (by tape) 16 inches and the outer $18\frac{3}{4}$ inches.

The general outline of this thigh-bone, judging from figs. 3 and 3 *a*, is quite in keeping with that of Mr. Johnson's specimen. Considering, however, that any points of specific value cannot be determined without careful comparisons, I am constrained to rely altogether on the similarities of contour; whilst as regards dimensions it must be conceded that there are very wide discrepancies. The relation, however, of the Cromer femur with that of the Mammoth would, on the score of size, be quite exceptional, and as regards contour there are the following differences:—In the latter there is a decided bulging about the junction of the middle and lower third externally, as seen in Pl. XIX, fig. 7, and a more general flattening of the shaft in the antero-posterior

[1] This is well seen likewise in pl. xvi, fig. 5, 'Ossem. Fossil.,' in a distal fragment from Italy.

[2] Nesti, op. cit., records a femur from the Val d'Arno, 1·400 m., being fully 2 inches longer than the above.

direction; whereas, in both Mr. Johnson's and Mr. Backhouse's specimens the former is absent, and the shaft is more round, especially about its middle.

The fragment (No. 288 of the Gunn Collection) from the Forest Bed at Walcot, Bacton, described by Falconer,[1] has the head and great trochanter wanting. The distal extremity, although not entire, and the remainder of the shaft, give a length of 47 inches. The girth at midshaft is 20 inches, and the breadth at the point of union of the condyles is 14 inches.

A ball of a femur from the beach of the Norfolk Coast, and No. 237 of the same collection, has a girth of 28 inches.

The distal epiphysis (No. 236) from the above collection, and evidently that of a young animal, as the pitting along the surface for attachment indicates, is represented (Pl. XXII, fig. 5) for the purpose of showing a more gaping intercondyloid fissure than any of the foregoing, or the Italian specimens figured by Cuvier.[2] Moreover, the trochlear depression of fig. 5 will be seen to be much shallower than that of the Mammoth (fig. 6), and the condyles do not converge. How far the discrepancies refer to a youthful condition of *E. meridionalis* or to another species is not easy to determine. That it should be referred to *E. antiquus*, according to the characters of the condyles from Walton,[3] is only in keeping with the appearance in them; but the peculiarity may be inconstant and of less value than a few instances appear to indicate; it is, however, worthy of notice.

As to the dimensions of fig. 5. The inner condyle is 19 inches by tape in the antero-posterior direction, and 4 inches in breadth. The outer is 17 by 4·5 inches, in breadth; the patellar sulcus 9·5 inches in breadth by tape.

12. TIBIA.

The tibia should furnish valuable diagnostic characters, and, supposing the following do not show variability in individuals, there would seem to be some important differences between them and the bones I have referred to *E. primigenius* and *E. antiquus*,[4] more especially as regards the configuration of the articular surfaces and the prominence or otherwise of the shin.

In Mr. Johnson's Collection there is an entire tibia, from Happisborough, of the following dimensions:

Length 24·5 inches.[5]

[1] Op. cit., vol. ii, p. 144.

[2] 'Ossem. Fossil.,' pls. xi, xiv, xvi.

[3] Page 62.

[4] Page 63 and 167.

[5] Nesti gives a tibia of 0·820 m., and Cuvier another Italian specimen of 0·825 m. ('Oss. Fossil.,' vol. ii, p. 226, pl. xvi, fig. 12).

Breadth across the head 8·5 inches.

Diameter of outer condyle (a. p. d.) 4·5 × 3·5 inches.

„ inner 5·5 × 4·5 inches.

Girth of head 25 inches.

„ midshaft 11·8 inches.

Distal articulation (a. p. d.) 5 inches.

Transverse 5·5 inches.

Girth, distal end, 18·8 inches.

Here the spine is prominent, with a pronounced concavity for the extensor muscles, to the extent of 5½ inches broad at the top, with much beetling of the former and deepening of the hollow posteriorly, as shown in the tibia of the Mammoth.

No. 242, Gunn Collection, is an injured tibia from Bacton, of much greater proportions than the last. The transverse diameter of the proximal articular surface is 12 inches, with a girth of head of 35 inches. Here there is also a prominent spine and deep pit for the muscles.

No. 243, Gunn Collection, is a distal end of a large tibia from the "soil of the Forest Bed." The antero-posterior and transverse diameters of the articulations are 5·5 and 6·5 inches respectively. The fibular facet is hollowed out and not erect; it is 4 × 3·5 inches in breadth.

No. 246, Gunn Collection, from the "Iron-pan, Forest Bed," is another enormous distal end, with an articular surface of nearly equilateral dimensions, being 6·5 in the a. p. d. to 6·5 inches in the transverse, consequently like that of *E. antiquus* (Pl. XIX, fig. 11 *a*). The fibular facet is small in this specimen as compared with the preceding, but, like it, it is almost horizontal.

No. 247 is a *beach* specimen, with a tarsal facet of 5 × 6. Here the fibular facet is also nearly horizontal, and large as compared with the last, being 2 × 2 inches.

No. 241 is an entire tibia encrusted with the "Iron Pan" of the Forest Bed. It clearly shows a much smaller animal than any of the foregoing from the same deposit. The length is only 2 feet, and breadth of proximal articulatory surface 8 by 4 inches in the antero-posterior direction. As far as size is a criterion, this bone may have belonged to the Mammoth.

No. 21,305, B. M., is a very large tibia from Ilford, and evidently the leg-bone of an adolescent individual, as the proximal epiphysis is wanting. The shaft is very stout, and altogether too large for the Mammoth. It may possibly belong to *E. antiquus*. The dimensions are—length 25 inches; girth, midshaft, 12·4 inches; distal articulatory aspect 4 a. p. d. by 5·5 inches in the transverse.

13. FIBULA.

There is a cast of an enormous fibula (No. 26,724, B. M.) from Cromer Forest Bed. The distal end is shown in Pl. XIX, fig. 3, and has been already referred to in connection with that of the Mammoth.[1]

The length is 32·8 inches.

Girth, midshaft, 5·8 inches.

Width, distal end, 5·5 inches.

Malleolar facet 4·5 (transverse) and 4·5 (height) inches.

The tibial articulation is not so erect as in the Mammoth, nor so horizontal as in the African Elephant.

The shaft is broad and flat superiorly, and rounded inferiorly, on its external surface.

No. 240, Gunn Collection, represents the proximal and distal extremities of an enormous fibula from what Mr. Gunn calls the "Soil of the Forest Bed." The tibial facet is a good deal inclined. The astragaloid aspect is 5 inches in breadth by 4 inches in height, and the entire breadth of the distal extremity is 5·5 inches.

No. 256 is nearly an entire fibula from the same situation. Its outer surface is nearly flat and broad, with narrow anterior and posterior sides. The bone is much compressed laterally at its proximal end. The distal articulation is 4·5 inches in breadth. The tibial facet, as in the others, has the articular surface at a low angle; the dimensions are $3{\cdot}5 \times 3$ inches.

The variable character of the shaft of the fibula in Elephants in general leaves little for specific characters, but, as regards dimensions, the above amply support the diagnosis as exhibited by the other elements of the skeleton of *Elephas meridionalis*.

14. TARSUS.

Astragalus.—This element of the foot attains to very large dimensions among the relics from the Forest Bed.

I have elsewhere indicated[2] the chief characters of this bone in relation to that of the Mammoth and recent species. An enormous astragal preserved in the Gunn Collection is 9×7 inches in its maximum width and antero-posterior length,[3] with a tibial aspect of $6 \times 5\frac{1}{2}$ in the a. p. d. diameter.

No. 254 of Mr. Savin's Collection from the Forest Bed, Overstrand, is 8 by 7 inches in the a. p. d. The tibial facet is 6·4 a. p. d. $\times$ 5·5 inches in the transverse direction.

[1] Page 169.

[2] Page 170.

[3] These considerably exceed the dimensions of a Val d'Arno specimen mentioned by Nesti, its length being 0·190 m., and maximum width, 0·163 m.

The external calcaneal facet is 4·5 × 4, and the internal 4·8 × 4 inches; the navicular is 6·4 in breadth, by 3·4 inches in height.

The left astragal, No. 33,425, B. M., from the Forest Bed, Happisborough (Pl. XIX, fig. 6) has the posterior angle almost obsolete, the same being usually pronounced in the Mammoth and Asiatic. The dimensions of the above are—

Length 7·5 inches.
Width 8·4 inches.
Tibial (a. p. d.) 6·4 by 6·4 inches (width).
Navicular facet 3·8 (height) by 7·8 inches (width).
Calcaneal facet (outer) 5 (a. p. d.) by 4 inches (width).
„ „ (inner) 4·8 by 3 inches.

Here, as in the preceding, the interosseous pit between the calcaneal facets is narrow in comparison with the Mammoth and Asiatic, and runs along the entire base.

The absence of pronounced angles and the usual concavities and convexities in the nicely interlocked bones of the recent wild animals, and the majority of the same in the Mammoth, may be another indication of the tardy movements of the colossal denizens of the Pre-glacial forests of East Anglia.

Calcaneum.—One of the largest heel-bones I have seen is in the possession of Mr. Randall Johnson, of Palling, near Stalham. The specimen was obtained at Horge, in the so-called "Norwich Crag." Its dimensions are—

Length 10 inches.[1]
Width 8 „
Outer astragal facet 5·2 × 2·2 inches.
Inner „ „ 5·3 × 2 inches.
Cuboidal facet 4 × 2·4 inches in height.
The girth behind the articulations, or neck of heel, is 14·5 inches.
The tibial facet (by tape) is 4·4 inches.

The National Collection contains two huge calcanea from Happisborough (Nos. 33,420 and 33,425); the former is somewhat injured, but preserves the following measurements:[2]

Length 9·8 inches.
Height 7·5 „
External astragal facet 3·8 (a. p. d.) by 3·4 inches.
Internal „ „ 4·5 „
Cuboidal 3 (height) by 5 inches (width).
Fibular facet 4·8 (a. p. d.) by 2 inches (height).

None of the articular surfaces in these two bones present the concavities so

[1] This dimension is exceeded by one recorded by Nesti from Val d'Arno, which was 0·295 m.=11·6 inches in length.

[2] Has been referred to previously at p. 64.

pronounced in the Asiatic Elephant and in the Mammoth; but the fibular facet is convex, as in them, although not to the same extent.

The calcaneum of the Mammoth, No. 33,419, B. M. (Pl. XIX, fig. 1), when compared with the above, shows certain differences, to wit, the prominent posterior and internal angle of that of the Mammoth, the relatively greater convexities of the tibial and perineal facets, which decidedly bulge out more in the Mammoth and (fig. 2) *E. antiquus*,[1] in both of which there is a wider interosseous pit, and in the Mammoth a more concave astragal aspect.

These points seem to prevail generally in the Mammoth and Asiatic Elephant. Again, the dorsal surface of the heel, which is usually narrow (not always, however) in the Mammoth, Asiatic, and *E. antiquus*, is always broad and round in the large bones from the Forest Bed. Moreover, the hollowing out of the inner side of the bone, so evident in the Mammoth generally and in the Asiatic, is not nearly so pronounced in the above and in the African Elephant. How much all these characters may depend on individual peculiarities I cannot say, but, as regards the Asiatic Elephant and the Mammoth, they appear pretty constant.

Naviculare.—Fragments of this bone are met with in collections made on the East coast of Norfolk, but, unless for their huge proportions, they do not present characters of importance.

No. 21,642, B. M., from Grays, Essex, exceeds very much the dimensions of any specimen of that of the Mammoth with which I am acquainted. Moreover, seeing that abundant remains of *E. antiquus* have been derived from the fluviatile deposits of the above locality, the probability is that it belongs to this species. The maximum width of the specimen is 9 inches, and the height 5·5.

No instance of a *cuboid* sufficiently large, as compared with the foregoing, has come under my notice.

Internal cuneiforme.—This bone is well represented by the enormous specimen, left side, No. 188 of the Gunn Collection (Pl. XXI, fig. 2), from the Norfolk coast. The following are its dimensions:

Extreme length 4·5 inches.

Greatest girth 8·5, the upper end being 8·2 and the lower 7·5 inches in girth.

The navicular facet (fig. 2 *a*) is 2×2·5, and the distal articulation (fig. 2 *b*) is 2 (a. p. d.), by 2 inches in width.

Thickness is 3 inches.

The proximal facet inclines gently upwards (fig. 2 *a*), whilst the distal aspect (fig. 2 *b*) is quite even and subtriangular.

There is a small round facet externally for the middle cuneiform.

The variation to which this bone is subject in the recent and extinct Elephants, and possibly also individually, renders its characters, at all events, worthy of record. In the

[1] Pages 64 and 170.

Asiatic and African Elephants, and in the Mammoth, it maintains much the same aspects, being flat and considerably greater in length than in breadth. But the above (Pl. XXI, fig. 2) differs from them in being round, with a more circular outer surface. As compared with the internal cuneiform of any of the above, it is, indeed, widely different.

I have not seen a *middle cuneiforme* of a size sufficiently large to correlate it with the large bones now under consideration.

External cuneiforme.—This element of the foot is well shown in the large bone, No. 187, from the Norfolk coast, in the Gunn Collection. The length is 4·4 inches, and maximum breadth 2·5; thickness 1·8 inches. Here the navicular surface shows the usual depression pronounced about the middle of the articular surface.

15. METATARSUS.

There are several examples of the digital proximal bones in the British Museum and in the Norwich Museum, and private collections in Norfolk and Suffolk.

A good illustration of the second metatarsal is afforded by No. 39,465, B. M., from the East Coast. It is five inches in length, with a maximum breadth of 3·4 inches.

The third metatarsal of a huge Elephant from Mundesley is preserved in Mr. Fitch's Collection. Its length is 7·4, and girth, midshaft, 8·4 inches.

The facet for the external cuneiform is 3 inches in height, by 3·4 inches in width.

The distal articular surface in the a. p. d. (by tape) is 7·4 inches, whilst the facet for the fourth metatarsal is 3 in height, by 1 inch in breadth.

In general appearance it seems to differ very little from the same bone in the Mammoth.

The fourth metatarsal is represented by a large bone in the British Museum from the East Coast, its maximum length and width being 6 and 3·5 inches respectively.

The fifth metatarsal is well shown by two short and extremely broad specimens in the Norwich Museum from the East Coast. One of these (not numbered) has the proximal articulation somewhat injured. The bone is flat on the dorsal aspect, with rounded sides. The length is $4\frac{1}{2}$ inches, and girth, midshaft, 9·4 inches. Another similar bone, No. 195 of the Gunn Collection, is also $4\frac{1}{2}$ inches in length, with a girth of 8·4 at the middle. The proximal articulation is $2{\cdot}5 \times 2{\cdot}5$ (tape), whilst the distal articular surface is 2·5 in the antero-posterior (by tape), and 2·4 inches in the transverse diameter. The upper surface of the articular surfaces are somewhat concave in both bones, with the lower borders protruding.

These two specimens show the circular cuboidal facet of the Mammoth, the same being ovoid in the African.

GENERAL SUMMARY.

The chief morphological characters and comparisons I have inferred from studies of the osseous remains of these three Elephants met with in the British Islands, and similar relics elsewhere, may be epitomised as follows:

As regards their exteriors, nothing is known further than the inference deduced from Arctic specimens of the *E. primigenius*, whose epidermis was clothed with long dark-coloured hair having a dense undergrowth of wool, as appertains to Mammals of cold climates.

As regards the *cranium* of *Elephas primigenius*, the frontal aspect is lengthened; summit narrow; space between the orbits in front narrow; large and long incisive sheaths with diverging alveoli; temporal fossa narrow; depression on the frontal; prominent lachrymal tubercle; zygoma under the level of the condyles, and nearly parallel with the molars; ovoid zygomatic arcade. (Pls. VI and VII.)

Mandible.—Broad, round mental region; small rostrum; erect diasteme, or nearly so; wide symphisial gutter; border of ascending ramus round posteriorly; condyles slightly compressed; neck of ditto narrow behind; dental canal opening upwards; short horizontal ramus; height to width of ascending ramus inconspicuous. (Pls. VIII and X.)

Cranium of E. antiquus.—Characters unknown.

Mandible.—Chin less rounded than *E. primigenius;* diasteme nearly erect; short rostrum; gutter not very wide; dental canal opening inwards; absence of much prominence of posterior border of ascending ramus; horizontal ramus more prolonged than in *E. primigenius;* greater difference between length and breadth of ascending ramus.

Cranium of E. meridionalis.—Shorter than in *E. primigenius*; vertex low and round; nasal aperture nearer to summit than in *E. primigenius;* inter-orbital space narrower; slight frontal depression; pointed lachrymal tubercle; zygoma much below the level of the condyles.

Mandible.—Chin usually less rounded than in either of the other two extinct species; low elevation of jaw at the commencement of the diasteme; long and narrow symphisial gutter; prolonged horizontal ramus, ending in a rather well-developed rostrum; greater height of ascending ramus in proportion to width as compared with the other two forms; absence of conspicuous bulging of ascending ramus posteriorly and at the junction with the horizontal ramus; dental canal directed backwards; narrowness of neck behind and below condyle. (Pl. XXII, fig. 2.)

I have already indicated several points of distinction between the dentitions of

the three forms of Elephants,[1] and shall now proceed to a more general epitome of the diagnostic values attached to the dental series of each species.

Dentition of Elephas primigenius.

Permanent incisor very long, spiral, and not remarkably thick near the alveolus; abnormalities not uncommon. (Pls. VI and VII.)

General characters of molar series.—Great breadth as compared with length; narrow and crowded ridges; tenuity of elements; absence of crimping generally; narrow disks; abnormalities pretty common.

Molars.—A pre-antepenultimate milk-molar has been inferred to be occasionally found. The first milk-molar varies from five to six ridges, including talons, the second from eight to eleven ridges, the third from eleven to fourteen ridges; the first true molar from eleven to seventeen ridges, the second from sixteen to eighteen ridges, the third from twenty to twenty-nine, or more, ridges. (Pls. VI—XIV, Pl. XX, fig. 3, and Pl. XXI, fig. 1.)

Dentition of Elephas antiquus.

Permanent incisor curved gently, like the recent species; thick at the alveolus and narrowing gradually towards the tip.[2]

General characters of molar series.—Crown generally narrow compared with the length; high ridges; enamel various, but usually thicker than in *E. primigenius;* crimping of machærides; central expansion and angulation of the disk; all the elements of the crown well developed; discs not aggregated; frequent abnormalities.

Molars.—The first milk-molar varies from four to five ridges, including talons, the second from seven to ten ridges, the third ten to thirteen ridges; the first true molar from eleven to fourteen ridges, the second from fourteen to fifteen ridges, the third from seventeen to twenty-three ridges. (Pls. I—V, Pl. XII, fig. 3, and Pl. XX, figs. 1 and 2.)

[1] Pages 65 and 185.

[2] The large collection of Mammoth's tusks from Ilford, in the Brady Collection, British Museum, shows considerable variability in the degree of curvature, and, as before observed (p. 8), there is one perfectly straight, or nearly so. This solitary specimen, Mr. Davies suggested, in the Catalogue (p. 28), might have appertained to *E. antiquus*, but I have shown that straight tusks are occasionally developed in the recent species, whilst, on the other hand, the only authenticated incisor of *E. antiquus* from Bracklesham Bay seems to show a curvature like that of the recent species; moreover, if the tusk was straight no one would have noted the circumstance sooner than Dr. Falconer, who saw the last-named specimen and another at Syracuse ('Pal. Mem.,' vol. ii, p. 188). I revert to these facts on account of Professor Boyd Dawkins's paper "On the Classification of the Tertiary Period," 'Quart. Journ. Geol. Soc. London,' vol. xxxvi, p. 379, and 'Early Man in Britain,' p. 104, in which he calls *E. antiquus* the "straight-tusked Elephant."

Dentition of Elephas meridionalis.

Permanent incisor enormous; curves gently, like the recent species; thickness maintained for nearly half its length, declining gradually towards the tip. Exceptions rare.

General characters of the molar series.—Crowns very broad; collines short in comparison with *E. antiquus*, and generally as compared with *E. primigenius;* enamel of discs thick and rarely crimped, but usually uneven, looped, or channelled; crown constituents generally in excess; plates wide apart, with thick wedges of cement. Exceptions not common.

Molars.—The first milk-molar has five ridges, including talons, the second has eight ridges, the third ten ridges; the first true molar from nine to eleven ridges, the second from eleven to thirteen ridges, the third from thirteen to sixteen ridges. Exceptions not common, except in the true molars. (Pl. XVII, fig. 8; Pl. XVIII, fig. 4; Pls. XXII—XXV.)

Spinal axis of Elephas primigenius.—The prominent "hog's back," so distinctive of the Asiatic as compared with the African Elephant, seems to have been a character also in the Mammoth.

Atlas.—Anterior articular surfaces semi-lunar; outer margins of the latter even and round; proportions between maximum height and width of neural and odontoid canals as 20 to 15. Exceptions rare. (Pl. XVII, fig. 1.)

Axis.—Neural canal nearly as broad as it is high; anterior articular surfaces subovate, with round external borders; odontoid process central. No exceptions out of several instances. (Pl. XVII, fig. 6.)

Spinal axis of Elephas antiquus: Atlas.—Anterior articular surfaces wider and more rounded than in *E. primigenius;* outer margins more circular; proportions between height and width as 22 to 20 (fig. 2). Differentiations made from a single specimen. (Pl. XVII, fig. 2.)

Axis.—Anterior articular surfaces subtriangular, and nearly as broad as long; outer margins projecting inferiorly and ovoid; odontoid process excentral, and near upper margin of centrum (fig. 5). Characters taken from a single specimen. (Pl. XVII, fig. 5.)

Spinal axis of Elephas meridionalis: Atlas.—Anterior articular surfaces asymmetrical and bulging inferiorly, with uneven external borders; proportions between height and width as 30 to 17. Last-named character not supported by any Italian specimen. (Pl. XVII, fig. 3.)

Axis.—Neural canal circular; anterior articular surfaces subcordate, with projecting external border; odontoid process excentral, and placed on the inferior margin of the centrum. (Pl. XVII, fig. 4.)

Scapula of E. primigenius.—Spine elevated; neck broad; recurved spine nearly central; glenoid cavity compressed laterally. (Pl. XV, fig. 1, and Pl. XXII, fig. 4.) Supported by numerous instances.

Scapula of E. antiquus.—Unknown.

Scapula of E. meridionalis.—Spine high and prominent; neck very broad; glenoid cavity wide inferiorly. (Pl. XVIII, fig. 3.) Supported by several instances.

Humerus of E. primigenius.—Robust; head and tuberosity compressed; deltoid crest prominent; deep and narrow bicipital groove; supinator ridge short and not very salient; border of condyles sharp and well defined; trochlear depression deep, with erect internal side; concavity internal to supinator ridge very pronounced. (Pl. XVI, fig. 1.)

Humerus of E. antiquus.—Not so robust as that of the Mammoth; deltoid crest not so prominent; supinator ridge less salient; hollow in front of supinator ridge very pronounced; trochlear depression deep and circular; outer condyle more globose than in the other two. (Pl. XVI, fig. 6.)

Humerus of E. meridionalis.—Not relatively so robust as in the Mammoth, but stouter than that of *E. antiquus;* head more circular than in the Mammoth; supinator ridge short, with little saliency; deltoid crest not very prominent as compared with the Mammoth; hollow in front of supinator ridge more pronounced in this and the last than in the Mammoth; trochlear depression like that of the Mammoth; margins of cubital articular surface not so defined as in the other two. (Pl. XVI, figs. 2 and 3.)

Cubitus of E. primigenius.—The radius commences to cross the ulna about its middle, and in a more oblique direction than in either of the recent species. The directions in the other two extinct forms are unknown to me.

Ulna.—Radial sulcus often deep; inner articular surface wide at the neck: posterior olecranon ridge rounded; external border well defined.

Radius.—Anterior surface round; upper and outer side of shaft less flattened than in the other two; round inner aspect of shaft. (Pl. XVIII, figs. 1 and 2.)

Cubitus in E. antiquus: Ulna.—Deep radial sulcus; head of olecranon arches more inwards than in the Mammoth.

Radius.—Upper and outer and inner sides of shaft more flat and round than in the Mammoth.

Cubitus of E. meridionalis: Ulna.—Radial sulcus shallow and wide; shaft not so flat as in the Mammoth.

Radius.—Anterior surface of shaft rather round, with outer and inner sides sloping and flat.

Manus of E. primigenius.—Minor distinctions subject to exceptions in *scaphoid, lunare,* and *cuneiforme; trapezium* and *trapezoid* inferred to be diagnostic (Pl. XIX, fig. 8, and Pl. XXI, fig. 3); proximal articular surfaces of the *third metacarpal* are diagnostic. (Pl. XVIII, fig. 7.)

Manus of E. antiquus.—Minor distinctions in *scaphoid, lunare,* and *cuneiforme; trape-*

zium and *trapezoid* inferred to be diagnostic (Pl. XIX, fig. 9, and Pl. XXI, fig. 4); proximal articular surfaces of *third metacarpal* are diagnostic. (Pl. XVIII, fig. 6.)

Manus of E. meridionalis.—Minor distinctions in *scaphoid*, *lunare*, and *cuneiforme*; *trapezium* inferred to be diagnostic (Pl. XIX, fig. 10); proximal articular surfaces of *third metacarpal* are diagnostic. (Pl. XVIII, fig. 5.)

Fifth metacarpal short and broad, with concave proximal articular surface. (Pl. XVIII, fig. 8.)

Pelvic girdle of E. primigenius.—Foramen ovale ovate, with the smaller end uppermost, and pronounced groove for the nerve and vessels; acetabulum higher than broad; niche of acetabulum wide, and opening on a flat surface; obturator border of ischium narrow, with prominent internal spine.

Pelvis of E. antiquus.—Unknown.

Pelvis of E. meridionalis is apparently like that of *E. primigenius*.

Femur of E. primigenius.—Neck short; great trochanter nearly level with the epiphysial junction of the head; bulging of external side at the commencement of the lower third; convergence of condyles more pronounced than in *E. antiquus*, and less than in *E. meridionalis*; variability of this character not unfrequent. (Pl. XIX, fig. 7, and Pl. XXII, fig. 6.)

Femur of E. antiquus.—Condyles less convergent than in the other two generally, but subject to considerable variability.

Femur of E. meridionalis.—Shaft more round generally; but more flattening of the upper third anteriorly and posteriorly than in *E. primigenius*. (Pl. XXVI, fig. 3.)

Crus of E. primigenius.—Prominent beetling spine; oblique fibular facet; circular femoral and tarsal articular surfaces. (Pl. XIX, figs. 12 and 4.)

Crus of E. antiquus.—Less obliquity of fibular facet; femoral and astragalar articular surfaces subcircular. (Pl. XIX, fig. 11.)

Crus of E. meridionalis.—Fibular facet nearly horizontal. (Pl. XIX, fig. 3.)

Pes of E. primigenius: Astragalus.—Posterior border uneven; uneven tibial surface; outer calcaneal facet nearly quadrilateral, inner crescentic; wide intervening fissure. (Pl. XIX, fig. 5.)

Calcaneum.—Heel prominent; deep hollow internally; dorsal aspect round; outer articular surface four sided, inner nearly triangular. (Pl. XIX, Fig. 1.)

Cuboid.—Internal and external sides subequal; calcaneal facet horizontal.

Pes of E. antiquus: Calcaneum.—Sides of heel equally compressed, and more round than in *E. primigenius*; peroneal facet large and prominent; outer articular surface ovoid, inner crescentic; intervening pit gaping more anteriorly than in *E. primigenius*. (Pl. XIX, fig. 2.)

Pes of E. meridionalis: Astragalus.—Posterior border concave; tibial surface even; outer calcaneal facet nearly quadrilateral, with uneven internal side, inner ovoidal; intervening pit wide at the middle. (Pl. XIX, fig. 6.)

Calcaneum.—Concavity inner side of heel not very pronounced, but more so than in *E. antiquus;* dorsal aspect of heel broad; outer articular surface nearly quadrilateral, inner ovoidal; peroneal surface less prominent than in either of the other two Elephants.

Internal cuneiforme.—Round shaft; proximal articular surface oblique; distal even and subtriangular. (Pl. XXI, fig. 2.)

Fifth metatarsal.—Round dorsal aspect; cuboidal facet circular.

First phalanx compressed laterally.

CONCLUDING OBSERVATIONS.

The osteological distinctions adduced in support of the existence of three species of Elephants in the British Islands during the Pliocene and Post-pliocene Periods suggest certain inferences in relation to their external characters and distributions.

The Mammoth seems to have preserved its thick covering of hair in both middle and high latitudes, as inferred from the Arctic specimens and the etching on the piece of tusk found in the cave of La Madelaine in the Dordogne. It was more slender than the other two forms, and apparently more active in its habits.

As regards dimensions there was considerable variability. No doubt there were local races, as with the two living Elephants; and these were characterised by external, as well as internal, distinctions. The small bones and teeth from the Ilford Brick-earths contrast with the larger dental and osseous elements from deposits in the neighbourhood and elsewhere throughout the Islands.

Reverting to the etching from Dordogne, the external ear, like that of the Asiatic, was apparently small as compared with the African; and, like the former, its skull showed a high crown, and the back behind the withers was prominent. These two characters are likewise confirmed by the skeleton.

In its long and dense pile of hair and bristles[1] streaming down face, cheeks, flanks, and quarters, the Mammoth must have presented a far more formidable appearance than might be inferred from its skeleton.

As regards height there seems to have been considerable variability. In comparison with the two recent species it may have averaged about 11 feet at the shoulder, whilst

[1] "Referring to the hair from Siberia in the Museum of the Royal College of Surgeons, Owen observes that it differed in length and thickness; some bristles, nearly black, were much thicker than horse-hair, and from twelve to eighteen inches long."—'British Fossil Mammals,' foot-note, p. 266.

individuals stood between 12 and 13 feet high. The smaller races, to wit, the denizens of ancient Ilford and other localities, scarcely equalled the dimensions of an ordinary-sized Asiatic Elephant.

The climate of Siberia does not appear to have caused a diminution in size, seeing that some of the largest teeth and bones have been brought from Polar lands.

The Ancient Elephant was both stouter and generally taller than the Mammoth, and presented even greater variability in height.

As to its external appearance, there is no evidence that it possessed a similar epidermic covering, but the probability is that the protection was necessary, at all events, during its sojourn in North-western Europe.

The Meridional Elephant was proportionally much taller than either of the foregoing; and individuals, judging from bones, must, in comparison with the living species, have attained a height of fully 14 feet at the shoulder. The high prominent crown of the Mammoth was less pronounced in this species; and, being a Pliocene Mammal, the probability is that it was not so densely clad in hair.

During their long struggles with climate and varying conditions, the lighter built Mammoth would have survived where its tardy compeers would have succumbed.

The Asiatic Elephant.

The almost naked epidermis of the adult recent Elephants, although general, is not an invariable distinction, even in full-grown individuals, especially among the denizens of the cooler regions of Asia. Indeed, the young often display this character of their ancestors, and the same has been observed in the case of the Rhinoceros of Asia.[1]

In outward appearance the Asiatic Elephant and Mammoth present similar characters, to wit, the high crown, lengthened anterior dorsal spines, and size of ears. The mutability in the size of the Asiatic Elephant is suggestive as regards extinct species, the various races being distinguished by outward characters[2] as well as skeletal differences. Thus, the small-sized race of Central India stands to the taller variety of the North-western Provinces much as the Mammoths of Ilford were to the larger denizens of other localities.

With reference to height there appears to be great variability. The tallest Asiatic Elephant measured by Mr. Sanderson, out of many hundreds, was 10 feet 5 inches at the shoulder; according to Tennent,[3] the Ceylon Elephant seldom exceeds 9 feet, and

[1] This is well shown in youthful individuals of both species at present (1880) in the Gardens of the Zoological Society of London. One of the young Asiatic Elephants lately presented to the Society by H.R.H. the Prince of Wales is more or less clad with hair, which Mr. Bartlett informs me has increased since its arrival.

[2] Falconer, 'Pal. Mem.,' vol. ii, p. 257.

[3] Tennent's 'Ceylon,' vol. iv, p. 291.

the ordinary herds do not average more than 8 feet.[1] The latter is about the height of the Bengal Elephant, which, however, varies considerably, not only in height but in stoutness, as shown by the designations of "slender-built" and "squat-built" Elephants of the Sal Forests. Sanderson asserts that few female Indian Elephants attain to a height of 8 feet at the shoulder.

The statement first advanced by Cuvier, that the Asiatic Elephant has a nail more on both fore and hind foot than in the African, may be pretty generally true; but, as regards the latter species, there are exceptions. Mr. Bartlett informs me that the female African Elephant in the Zoological Gardens has four nails on the hind foot, whilst the male has only three, and that sometimes the Asiatic has five instead of four nails on the hind foot.

It has been asserted, moreover, that the Elephant of Asia displays a greater degree of intelligence and aptitude for instruction. But I am assured by the above-named excellent authority that, as far as the two African individuals now in the Zoological Gardens are concerned, where they have been reared from the time they were calves, they are "quite equal in intelligence to the Asiatic, and far more active, and that the male is as good tempered as it is possible for any animal to be."

The African Elephant.

The natural history of the African Elephant is not so well known as that of its more Eastern congener, at the same time it is easily distinguished from the latter. Neither the crown of the head nor the back is so convex, and the ears are much broader, and it is generally taller. There seems, however, considerable variability in the last-named character. Livingstone, who had seen more Elephants than, perhaps, any African traveller, observes that those living on the banks of the Zambesi averaged about 9 feet 10 inches in height, whilst further south the Elephants attained a height of 12 feet;[2] whilst Sir Samuel Baker considers that the Elephant at the sources of the Nile stands about 10 feet 6 inches. Again, Livingstone speaks of a small race only 5 feet 8 inches in height,[3] which would be about the dimensions of the dwarf *Elephas Mnaidriensis* of Adams.[4]

Distribution.—The view that all the remains of Elephants met with in British and European strata represent the variable conditions of a single species should receive support in the distribution of the animal in space and in time. Now, among the vast quantities of molars and bones from Polar regions, not a trace of teeth referable to the forms to which the names *E. antiquus* and *E. meridionalis* have been given has been

[1] The Cingalese Elephant, although higher at the fore quarters than the Sal Forest Elephant, is otherwise not so bulky.

[2] 'Travels in South Africa,' p. 562. The fine male in the Zoological Gardens, Mr. Bartlett informs me, although not yet full grown, is 11 feet 6 inches; and the female, much younger, is 8 feet 2 inches in height.

[3] 'Last Journals,' vol. ii, p. 29.

[4] 'Trans. Zool. Soc.,' vol. ix, p. 116.

found. Again, the huge teeth and bones referable to the last-named form have not hitherto been found in deposits of a Post-glacial age with those of *E. primigenius* and *E. antiquus*.

The characters so distinctive of the worn crown of *E. primigenius* are maintained throughout its geographical and geological distributions. The close-packed and attenuated wedges of enamel and dentine are preserved equally in molars from the British Isles, German Ocean, European Continent, Arctic Siberia and North America, Canada, and the United States. In Europe they are found often side by side with the teeth and bones of the other two forms, and again, in North America, with a decidedly different form of tooth. But the spiral tusk, so prevalent in all skulls containing grinders of the characters referred to the Mammoth, has not been seen in crania holding molars assigned to the *E. meridionalis;* and, as far as fragmentary instances of the *E. antiquus* are concerned, it is also absent, its place being taken by a defensor similar in outline to that of the two recent Elephants.

Again, if the molars of *E. primigenius*, as stated by a few palæontologists, are seen shading off into thick-plated varieties, provided that such assertions are meant to convey a belief that any two or more of these so-called species can be united by a series of grinders graduating into one another, how is it that this remarkable variability is not present in the teeth from Polar lands?

Then, as to the cranium of *E. primigenius* and *E. meridionalis*—unfortunately, that of *E. antiquus* is unknown—can any two skulls of allied species be more distinct? In the case of the two recent species the cranial characters never vary, and are as broadly specified as are the skulls of the Mammoth, Meridional, and probably that of the Ancient Elephants.

The various physical features and climates with which the Mammoth had to contend throughout its wide distribution in space and in time were well calculated to bring about modifications of its external and internal skeleton. And these, no doubt, took place within certain limits I have indicated; but the ancestral branches from which the *E. primigenius*, *E. antiquus*, and *E. meridionalis* sprang, and the regions in which their evolutions took place, were both geographically and geologically remote from the British Islands, at all events, and from the periods of time represented by the deposits in which the remains of the former are found. No doubt the time will come when the palæontologist can be enabled to bridge over many gaps at present both wide and well defined.

Although a few facts point definitely towards a union of several forms of Proboscideans, at present admitted to be distinct species, it must be conceded that by far the greater number of these are based merely on single characters subject to exceptional cases, and as yet unsupported by other and far more important skeletal elements. It will therefore be granted that the apparent resemblances between certain so-called species, although morphological facts, must be subject to acceptance or rejection in accordance with the advancement of science. At present I see no good—on the con-

trary, much confusion, in making hasty assumptions without the confirmation of reality. As to persistency of character throughout long periods of time, we find many cotemporaries of the Mammoth, to wit, the Red Deer, Elk, Reindeer, Wolf, and others, maintaining, at all events, their skeletal elements unchanged, however much their Post-pliocene ancestors may have differed from them in external covering.

The association, therefore, of the Mammoth, in North-western, Central, and Southern Europe, with the Ancient and Meridional Elephants, its solitary sojourn in the Arctic and sub-Arctic regions of the Old and New Worlds, and its companionship in the United States with the so-called Columbian Elephant, and maintaining throughout these vast areas the well-marked dental and osseous characters by which it is differentiated from them, are certainly cogent evidences of its claims to be considered a distinct species. As to its range in time, we find the main points connected with, at all events, its dental elements, continuing from the Pliocene Period up to the Neolithic Age.

The Ancient Elephant has left its remains abundantly in North-western, Central, and Southern Europe, also in Northern Africa and probably Hindostan, where, at all events a close ally, if not the same species, existed under the name of the Narbudda Elephant (*E. Namadicus*). The Ancient Elephant displayed far more divergent skeletal characters than either of its congeners, and ranged in time from the Pliocene into the Post-pliocene Periods. It may have become extinct before the Mammoth; at all events the two were cotemporaneous in England during the Cave Period, and the depositions of the drifts, valley-gravels, brick-earths, and possibly the boulder-clays.[1]

The Meridional Elephant has been traced from South-eastern England to the Continent of Europe, including the coast of Holland and Belgium, Northern, Middle, and Southern France, Italy, and South-eastern Europe.[2] Its Eastern congener, the broad-fronted Elephant (*E. planifrons*), claims certain marked relationships.

The differentiations established by Falconer that three well-marked species may be recognised among the fossil remains of Elephants met with in Europe receive further confirmation from the data I have recorded in this Monograph. These, as well as other species, be characterised by the variations in their grinders, which, although valuable as one of the chief means in forming a diagnosis, should, in all cases, go hand in hand with other elements of the skeleton. But, unfortunately, the difficulties in attempts to unite the teeth and bones are frequently embarrassing, owing to the association of remains of two or more species.

No more pointed instance of an involved collection, made, doubtless, under many difficulties, can be adduced than that brought together by Falconer and Cautley in the Sewalik Hills.[3] This may be owing to precise records not having been made during the

[1] Boyd Dawkins, 'Quart. Journ. Geol. Soc.,' vol. xxxv, p. 139.

[2] Lartet, 'Bullet. Société. Géol. de France,' 3rd series, t. xvi, p. 500.

[3] Vast quantities of spinal and appendicular elements of Mastodons and Elephants from the above situations, are now in the British Museum, but in the absence of typical examples, it is at present impossible to assign any single bone to its appropriate cranium and molar.

excavations. It must be conceded that until the Asiatic fossil forms have been fully described no sound deductions in connection with the pedigrees of Proboscideans in general are likely to be arrived at.

With reference to the Proboscidean remains from British strata, the abundant materials of the Mammoth skeleton from the Arctic regions in the Museums of this country afford ample means for comparative purposes. In consideration, however, of accidental intrusions, I have invariably, wherever Arctic types were available, preferred them, especially in the cases of the fragmentary elements of the appendicular skeleton. The association of the teeth and bones of the three species in Pre-glacial deposits, and of the Mammoth and *E. antiquus* in Post-pliocene strata, leaves no doubt that they were not only cotemporaneous, but must have often herded together. The same, moreover, was pointedly the case with the Sewalik and Maltese species. Considering, therefore, the marked variability displayed by the skeletal elements of the three extinct British Elephants, we may, I think, fairly suppose that by means of natural selection and its conditions, mutability giving rise to distinct races, and varieties would, in process of time, produce species such as are ordinarily accepted by the term. Referring even to the Mammoth, as compared with *E. antiquus*, there are well-marked distinctions between the teeth and bones met with in the brick-earths of Ilford and typical molars from neighbouring localities and the Arctic regions. These two pronounced varieties are easily recognised from each other by their dimensions and characters. Now, although any one who will take the trouble to examine the Brady Collection in the British Museum, and compare the teeth and bones with the same parts from other British localities and foreign countries, cannot doubt that they represent one species; at the same time it must be admitted that they present considerable variability. This mutability is very much more apparent in the remains of *E. antiquus*, and to a small extent with *E. meridionalis*, as far as remains of the latter are at present known. These mutabilities, more especially in the case of the Mammoth, I cannot help believing were never fully recognised by Falconer.[1]

The following relationships between the extinct and recent Elephants, indicated either solely by their dentitions, or in combination with the skeleton generally and distribution, must be considered, for the most part, as merely approximations subject to the corrections and additions of a progressive branch of scientific research.

[1] I refer especially to one of the last sentences he wrote on this subject, where he states that the Mammoth retained its "organs of locomotion and digestion all but unchanged through an enormous lapse of ages." Posthumous essay on "Primeval Man and his Contemporaries," 1863, 'Pal. Mem.,' vol. ii, p. 587.

Elephas primigenius.

The correlation by Falconer of *E. Hysudricus*, a Miocene form, with *E. primigenius* and other allies in his subgenus *Euelephas*, on account of similarities in the ridge formula of their grinders, indicates an alliance of some kind with the Asiatic Elephant and the Mammoth; but this is as much as can be advanced at present.

The nearest approach to the latter, established by the ridge formula and general osteological characters, is presented by the skeleton of the living denizen of Asia. The disagreements displayed in the tusks, crown patterns of the grinders, and epidermic coverings, are assuredly very pronounced, and require further evidences of relationship before one can break down the barrier existing between them, inasmuch as there must have been considerable intermediate modifications of these parts in either direction.

The molars of *E. Armeniacus*, described by Falconer, and placed by him as intermediate in character between the Mammoth and the Asiatic Elephant,[1] present assuredly broader crowns than ordinarily appertain to the grinders of the latter. Consequently, this is one step towards the union of the two; otherwise the Armenian form, as far as the specimens in the British Museum are concerned, have failed in my hands, after repeated comparisons, to show any appreciable differences between them and grinders of the Asiatic Elephant. Indeed, should the Italian specimens,[2] referred to by Falconer, turn out identical with the Armenian molars, it might be a matter for speculation whether or not we should look to the evolvement of the Mammoth from *E. Asiaticus*, rather than the opposite. The plaited enamel of the living species has numerous homologies among fossil teeth of the Sewalik Elephants, whereas the typical molar of the Mammoth stands widely apart from any Eastern form.

The grinders of *Elephas Columbi*, Falconer,[3] represented by the specimens in the British Museum and the Royal College of Surgeons of England, occupy a similar position to the Mammoth's grinders met with in North America as do those of the Asiatic and Armenian Elephants to the teeth of that form found in Europe and boreal Asia. Moreover, the extreme breadth of the crowns of certain molars of *E. Columbi*—and there seems to be considerable variability—are in keeping with that of the Armenian Elephant,[4] from which it would be difficult to make out any differences of importance. In North America we find the Mammoth's remains restricted to the Arctic and temperate regions, whilst the plaited tooth of *E. Columbi* predominates in the more southern and warm, temperate climates. Again, in Asia the thin-plated molar of the Mammoth is restricted to Siberia, whilst the fluted enamel of the disc is repeated in the living denizen of subtropical Asia.

[1] Op. cit., vol. ii, p. 247.

[2] Op. cit., vol. ii, p. 249.

[3] Op. cit., vol. ii, p. 219.

[4] Falconer, 'Nat. His. Review,' 1863, plates i and ii. Same reduced, 'Pal. Mem.,' vol. ii, plate x.

Elephas antiquus.

If I am correct in assigning the three well-marked varieties of teeth[1] to *E. antiquus*, the following inferences may be drawn in connection with their relations to the molars and other remains of allied forms hitherto regarded as distinct species:

1st. The massive broad crown of *E. antiquus*, with its ridges closely approximated, and not unfrequently devoid of, or only partially displaying, angulations, central expansions, and crimping of the enamel discs, so characteristic of the long narrow tooth, coupled with the characters of the bones, appears to assimilate closely to the same elements of the skeleton of *E. Namadicus* of India. Molars and bones of the above description are plentiful in collections from British and European Pliocene and Post-pliocene strata. But these affinities do not end here, for on comparing the above with the fluted crowns of *E. Asiaticus*, *E. Armeniacus*, *E. Columbi*,[2] and certain teeth assigned to *E. primigenius*, very close relationships are likewise traceable. These are most apparent in crowns of the latter, in which all the characters of the broad massive molar of *E. antiquus* are represented. Hypothetically, one might argue that from the Miocene *E. Hysudricus* sprang the *E. Namadicus* and *E. antiquus*, from which *E. Asiaticus*, *E. Armeniacus*, *E. Columbi*, and *E. primigenius* branched off.

2nd. The long narrow, and often arcuated crown of *E. antiquus*, on which the species was first differentiated, although the most common variety, as far as British specimens are concerned, can be, without difficulty, traced in a series towards the third variety, to which Falconer assigned the name of *E. priscus*, from its close agreement with the tooth of *E. Africanus*. It was only after a more extended experience, that he withdrew that name and placed it in the same category with *E. antiquus*. The instances recorded elsewhere of the variety in question[3] include several colossal teeth of Elephants whose dimensions must have rivalled those of the broad crown, and even the teeth of *E. meridionalis*, whilst other grinders and bones belonging to animals with the narrow crown must be referred to much smaller individuals.

The discs of these molars generally display well-marked angulations and expansions (Pl. V, fig. 1), although these are not always on every disc.

The degrees of crimping and thickness of the enamel, dentine, and cement are variable. Again, when the elements are in excess, and the crimping very feeble, or nearly absent, and the central expansions and angulations pronounced,[4] the sculpturing of the

Page 31, and elsewhere.

[2] The molar of *E. Columbi*, 'Pal. Mem.,' vol. ii, p. 222, and in vol. v, plate iv, of the 'Geologist,' and No. 33,218 of the Palæontological Collection, B. M.; also No $\frac{20,702}{A}$, B. M. The characters of their crowns closely resemble the following examples of the broad variety of *E. antiquus*. The molar from Happisborough, No. 33,327, B. M., alluded to at p. 37, and No. 27,907, B. M., from Clacton, at p. 33, plate IV, fig. 1, and also plates V, fig. 1, and XX, figs. 1 and 2.

[3] Page 33.

[4] See molar 39,370, B. M., from Gray's, Essex, 'Pal. Mem.,' vol. ii, pl. xvii, fig. 1, and part i, p. 34.

tooth is scarcely to be differentiated from crowns of *E. Africanus;* but this agreement is not confined to it alone, inasmuch as their bones have been shown to present many affinities.

Again, one of the most remarkable resemblances in connection with this description of molar, and, in no small degree, the bones likewise, is presented by their relations to the same elements in the dwarf Elephants of Malta, as pointed out in my Monograph on these pigmy forms.[1]

From these data it might be conjectured that the African and Maltese Elephants were evolved from the narrow-crowned variety of *E. antiquus*.

Elephas meridionalis.

Frequent allusions have been made in preceding pages to the relations of the dental elements of the above with those of the *E. planifrons* of the Sewalik Hills of Northern India. The materials of this Miocene Elephant, although somewhat scanty, at all events, as far as the grinders are concerned, show a decided relationship with *E. meridionalis*. Both were of stupendous dimensions, and show by no means such tendencies to variability as displayed in the dental and osseous structure of *E. antiquus*. The only striking resemblances between certain molars of the former and the latter are furnished by such enormous and thick-plated molars as the remarkable tooth from Culham,[2] in the Oxford University Museum, and another from Whittlesea, in the Museum of Zoology of Cambridge University,[3] and the largest ultimate molars of *E. meridionalis*. But whilst these agree as to the thickness of the dental elements, they differ in the sculpturings of the crowns; indeed, the disposition to thick- and thin-plated varieties in all the British, Maltese, and, to a less extent, the recent species, shows that these conditions alone are not trustworthy diagnostic characters. The presence of a pre-molar in *E. planifrons* and its suppression in *E. meridionalis* constitute an important distinction, but, like the pre-antepenultimate milk-molar, may not be an invariable condition.

The passage from the sub-genus *Stegodon* towards *Loxodon* has been thus indicated by Falconer:—"The ciphers yielded by the 'ridge formula' of *E.* (*Stegodon*) *insignis* place the species in close affinity with the Loxodons, and more particularly with the species named *E.* (*Lox.*) *planifrons*."[4] The former, according to this authority, is of both Miocene and Pliocene, and the latter Miocene.

Again, the natural affinities between the Mastodons and the Stegodons are shown by

Also, and the very suggestive example discovered by Ramsay a few years ago in a deposit near Tangier, 'Quart. Journ. Geol. Soc.,' vol. xxxiv, p. 514, fig. 9.

[1] 'Trans. Zool. Soc. London,' vol. ix, p. 108, and plates iii—ix inclusive.

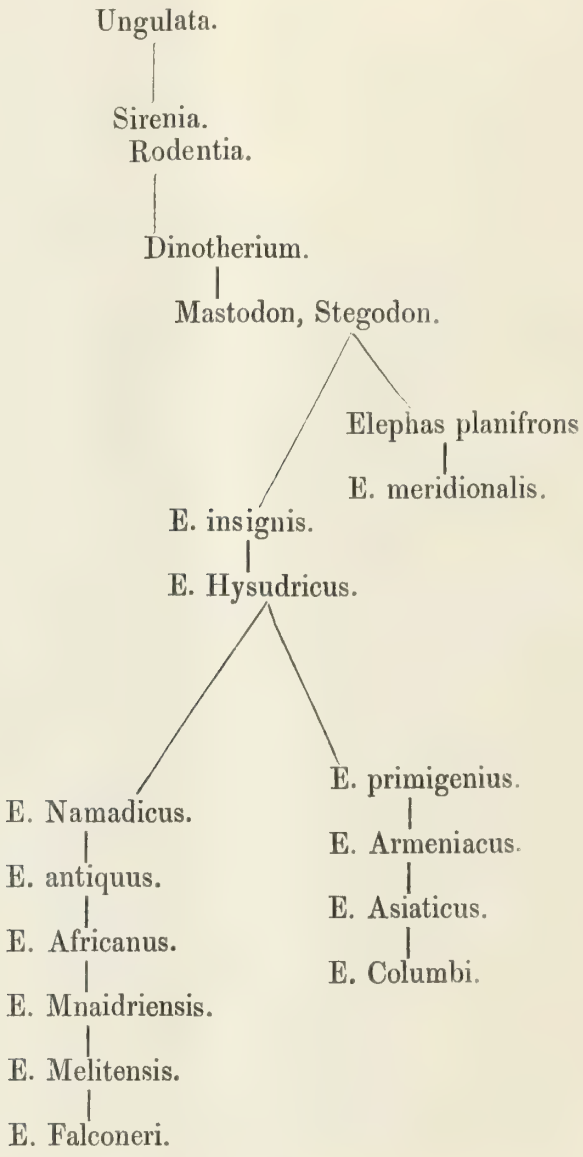
[2] Page 33.

[3] Page 177.

[4] Op. cit., vol. ii, p. 86.

Falconer in the teeth of *Mastodon longirostris* and *M. latidens* as compared with *Stegodon Cliftii*, *St. bombifrons*, and *St. insignis*.[1]

All these and other allied Proboscidean and Mammalian affinities, as far as they go, might be arranged in the following manner:



[1] Op. cit., vol. ii, p. 82.

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[1] The author is indebted to the Rev. T. Wiltshire, M.A., F.G.S., Secretary of the Palæontographical Society, for the pains he has taken in the compilation of this Index.

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PLATE XVI.

Figs. 1, 1 *a*, and 1 *b*. Anterior, posterior, and inferior views of a humerus of *E. primigenius*, No. 30,531, British Museum, from the Bay of Galway. (About $\frac{1}{8}$ natural size.)

Figs 2 and 2 *a*. Anterior and posterior views of a humerus of *E. meridionalis*, No. 200, Gunn Collection, Norwich Museum, from the Forest Bed, coast of Norfolk. (About $\frac{1}{11}$ natural size.)

Fig. 3. Inferior view of the distal extremity of a humerus of *E. meridionalis*, Norwich Museum, from the Forest Bed, Rockland. (About $\frac{1}{11}$ natural size.)

Figs. 4, 4 *a*, and 4 *b*. Anterior, posterior, and inferior views of a humerus of *E. Asiaticus*, No. 2744 E, in the Museum of the Royal College of Surgeons, London. (About $\frac{1}{8}$ natural size.)

Figs. 5, 5 *a*, and 5 *b*. Anterior, posterior, and inferior views of a humerus of *E. Africanus*, No. 708 H, British Museum. (About $\frac{1}{8}$ natural size.)

Figs. 6, 6 *a*, and 6 *b*. Anterior, posterior, and inferior views of a humerus of *E. antiquus*, in the Cotton Collection, Jermyn Street Museum, from the brick-earths of Ilford, Essex. (About $\frac{1}{8}$ natural size.)

The expenses connected with the drawing of the specimens upon the stone in connection with Plates XVI, XX, XXI, XXII, and XXV, were defrayed by a grant allocated by the Government Grant Committee of the Royal Society for the Promotion of Scientific Research.

Fig 1ª
Fig 1
Fig 2ª
Fig. 4
Fig. 5.
Fig. 1ᵇ.
Fig 3
Fig. 4ᵇ.
Fig. 5ᵇ.
Fig. 6ᵇ.
Fig. 6ª
Fig. 6
Fig 2.
Fig. 4ª.
Fig. 5ª.

PLATE XVII.

Fig. 1. Front view of an atlas of *E. primigenius*, Nos. 45,025 and $\frac{C}{93}$ of the Brady Collection, British Museum, from Ilford, Essex. ($\frac{1}{4}$ natural size.)

Fig. 2. Front view of an atlas of *E. antiquus*, Nos. 45,200 and $\frac{D}{9}$ of the Brady Collection, British Museum, from Ilford, Essex. ($\frac{1}{4}$ natural size.)

Fig. 3. Front view of an atlas of *E. meridionalis*, No. 36,436, British Museum, dredged off the coast of Essex. ($\frac{1}{4}$ natural size.)

Fig. 4. Front view of an axis of *E. meridionalis*, No. 27,872, British Museum, dredged off the coast of Essex. ($\frac{1}{4}$ natural size.)

Fig. 5. Front view of an axis of *E. antiquus*, Nos. 45,201 and $\frac{D}{10}$ of the Brady Collection, British Museum, from Ilford. ($\frac{1}{4}$ natural size.)

Fig. 6. Front view of an axis of *E. primigenius*, Nos. 45,030 and $\frac{C}{98}$ of the Brady Collection, British Museum, from Ilford. ($\frac{1}{4}$ natural size.)

Fig. 7. Anterior view of a first dorsal vertebra of *E. primigenius* (*?*), in the possession of J. J. Colman, Esq., M.P., of Corton, Suffolk, dredged off Lowestoft, Suffolk. (About $\frac{1}{4}$ natural size.)

Fig. 8. Crown view of a right upper last milk molar of *E. meridionalis*, in the King Collection, Jermyn Street Museum, from the Forest Bed, Norfolk. (Natural size.)

Fig.1

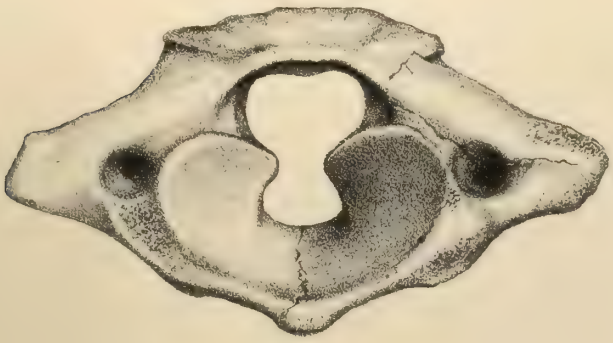
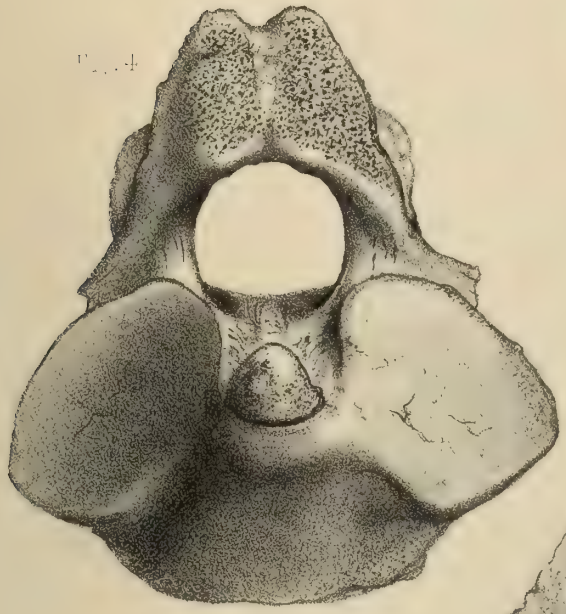


Fig.2

Fig.4



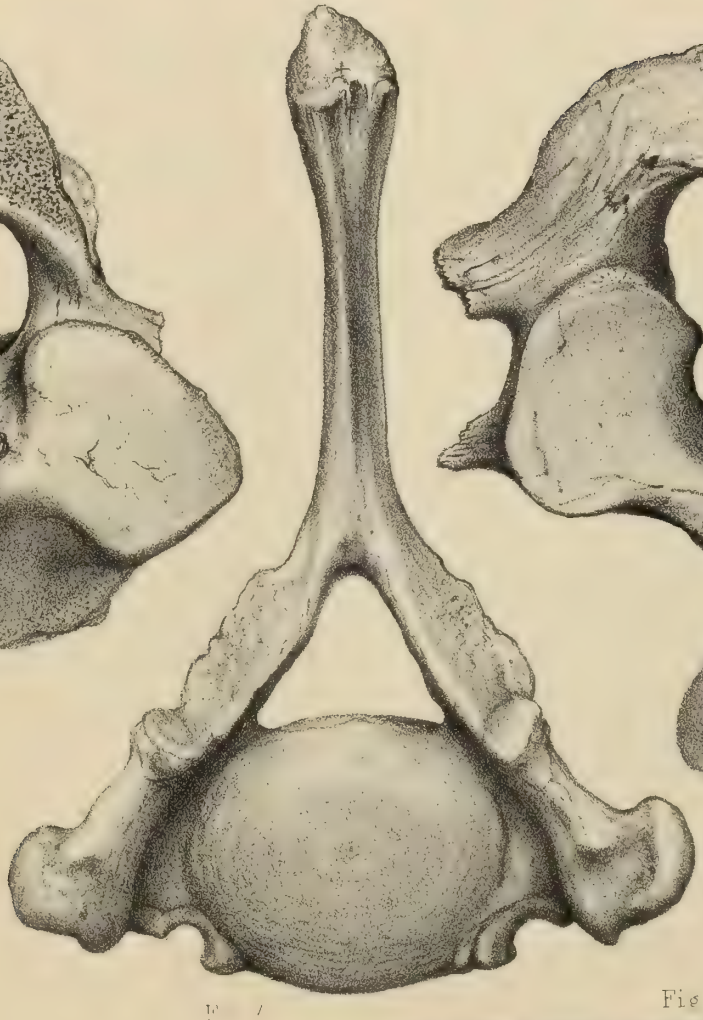
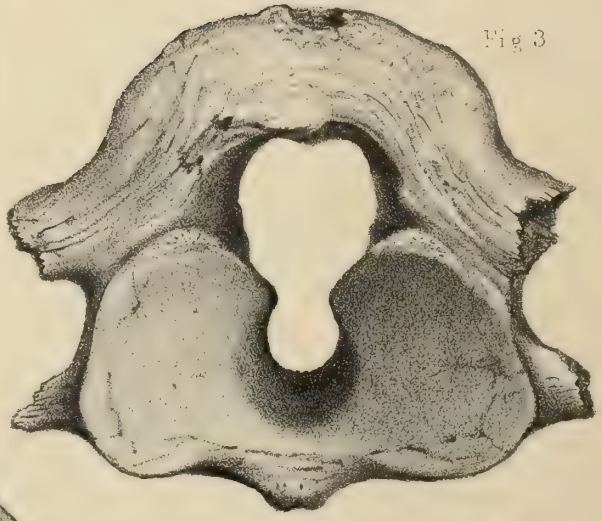


Fig.3



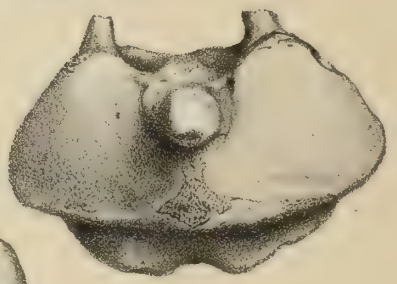


Fig.5.

Fig.6.

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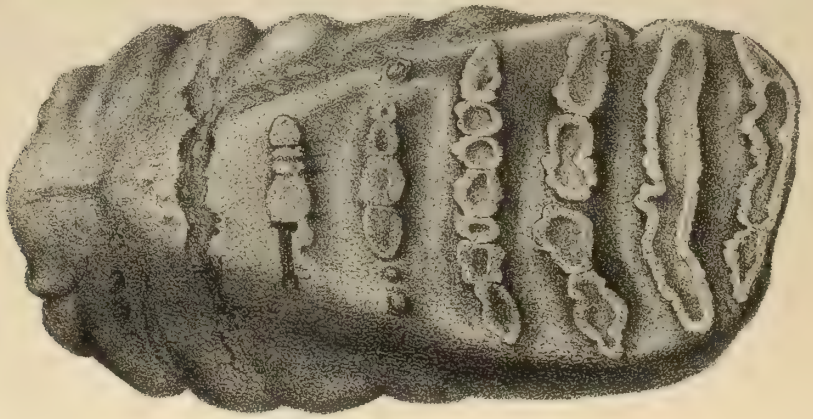

PLATE XVIII.

Fig. 1. A right cubitus of *E. primigenius*. Fig. 1 *a*. Proximal end of the ulna. Fig. 1 *b*. Distal aspect. No. 38,011, British Museum.

Fig. 2. Radius, No. 38,012, detached from fig. 1. Fig. 2 *a*. Distal aspect. Fig. 2 *b*. Proximal aspect. Both from Ilford, Essex. ($\frac{1}{4}$ natural size.)

Fig. 3. Glenoid cavity of a left scapula of *E. meridionalis*, No. 275, Gunn Collection, Norwich Museum, from the Forest Bed, Norfolk coast. ($\frac{1}{4}$ natural size.)

Fig. 4. Fragment of a true molar of *E. meridionalis*, No. $\frac{G}{102}$, Jermyn Street Museum, from the Forest Bed at Mundesley, Norfolk coast. (Natural size.)

No. 5. Proximal articular aspect of a third metacarpal of *E. meridionalis*, No. 33,428, British Museum, from Happisborough, Norfolk Coast. ($\frac{1}{2}$ natural size.)

Fig. 6. Proximal articular surface of a third metacarpal of *E. antiquus*, No. 18,248, British Museum, from Grays, Essex. ($\frac{1}{2}$ natural size.)

Fig. 7. Proximal articular surface of a third metacarpal of *E. primigenius*, No. 36,232, British Museum, from Ilford, Essex. ($\frac{1}{2}$ natural size.)

Figs. 8 and 8 *a*. Fifth metacarpal, with proximal articular surface, of *E. meridionalis*, No. 33,433, British Museum, from Happisborough, coast of Norfolk. ($\frac{1}{3}$ natural size.)

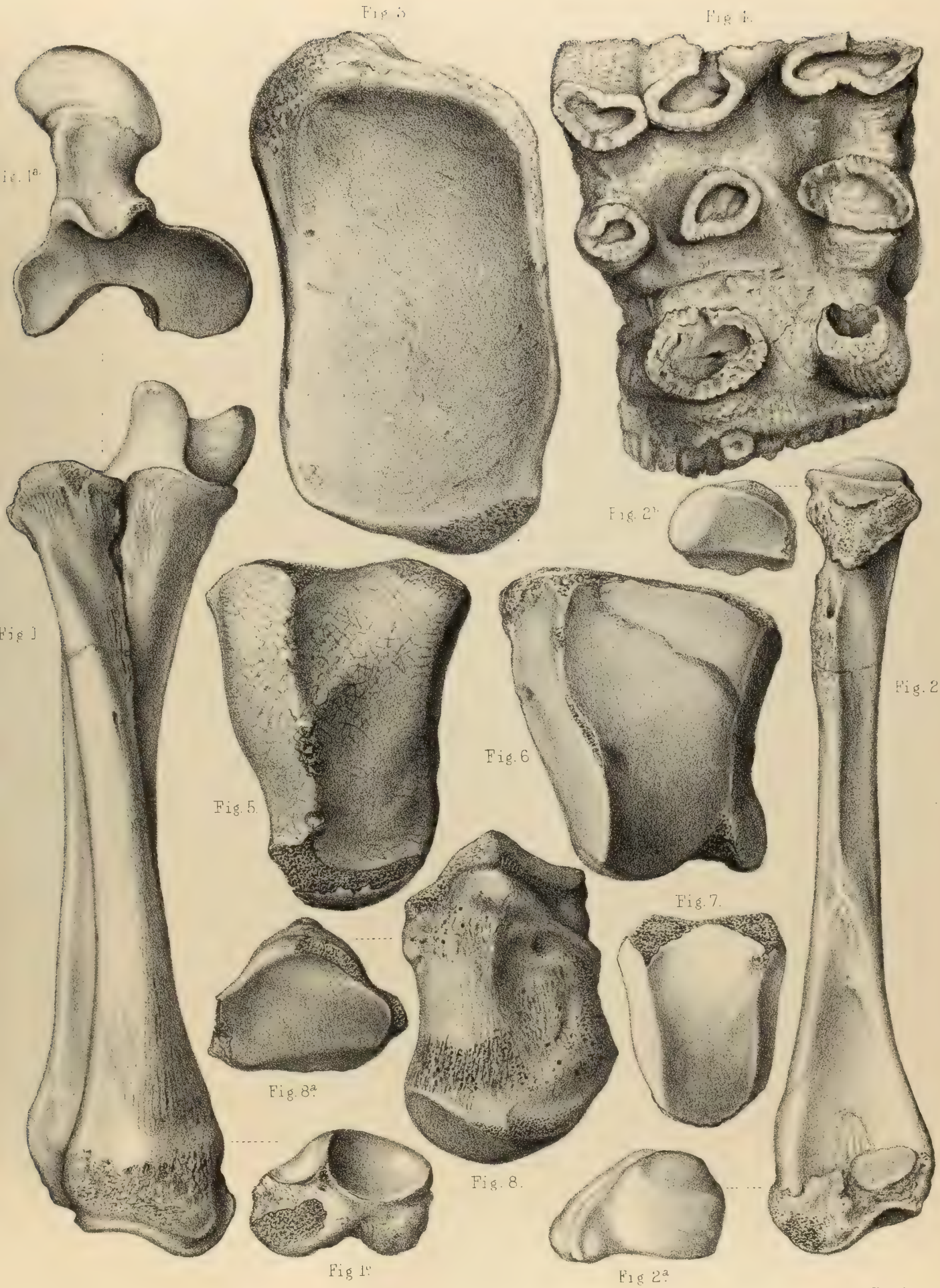

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PLATE XIX.

Fig. 1. Upper view of a right calcaneum of *E. primigenius*, Nos. 33,419, British Museum, from Ilford, Essex. ($\frac{1}{3}$ natural size.)

Fig. 2. Upper view of a left calcaneum of *E. antiquus*, No. 27,940, British Museum, from Grays, Essex. ($\frac{1}{3}$ natural size.)

Fig. 3. Distal internal view of a fibula of *E. meridionalis*, No. 26,724, British Museum, from Forest Bed, Cromer, Norfolk. ($\frac{1}{5}$ natural size.)

Fig. 4. Distal internal view of fibula of *E. primigenius*, No. $\frac{C}{220}$ of the Brady Collection, British Museum, from Ilford. ($\frac{1}{5}$ natural size.)

Fig. 5. Inferior view of a right astragalus of *E. primigenius*, Nos. 45,171 and $\frac{C}{221}$ of the Brady Collection, British Museum, from Ilford. ($\frac{1}{3}$ natural size.)

Fig. 6. Inferior view of a left astragalus of *E. meridionalis*, No. 33,425, British Museum, from the Forest Bed, Happisborough, Norfolk coast. ($\frac{1}{3}$ natural size.)

Figs. 7 and 7*a*. Front and inferior aspects of a right femur of *E. primigenius*, No. $\frac{C}{190}$ of the Brady Collection, British Museum, from Ilford. ($\frac{1}{8}$ natural size.)

Figs. 8, 8 *a*, and 8 *b*. External, upper, and lower views of a left trapezium of *E. primigenius*, No. 36,611, British Museum, from Maidstone, Kent. ($\frac{1}{2}$ natural size.)

Figs. 9, 9 *a*, and 9 *b*. External, upper, and lower views of a right trapezium of *E. antiquus*, No. 20,821, British Museum, from Grays, Essex. ($\frac{1}{2}$ natural size.)

Figs. 10, 10 *a*, and 10 *b*. External, upper, and lower views of a right *trapezium* of *E. meridionalis* (?), No. 33,418, British Museum, from East Coast, Norfolk. ($\frac{1}{2}$ natural size.)

Figs. 11, 11 *a*, and 11 *b*. Anterior, superior, and inferior views of a tibia of *E. antiquus* (?), No. 40,134, British Museum, from the Valley of the Thames. ($\frac{1}{8}$ natural size.)

Figs. 12, 12 *a*, and 12 *b*. Anterior, superior, and inferior views of a tibia of *E. primigenius*, No. $\frac{C}{213}$ of the Brady Collection, British Museum, from Ilford. ($\frac{1}{8}$ natural size.)

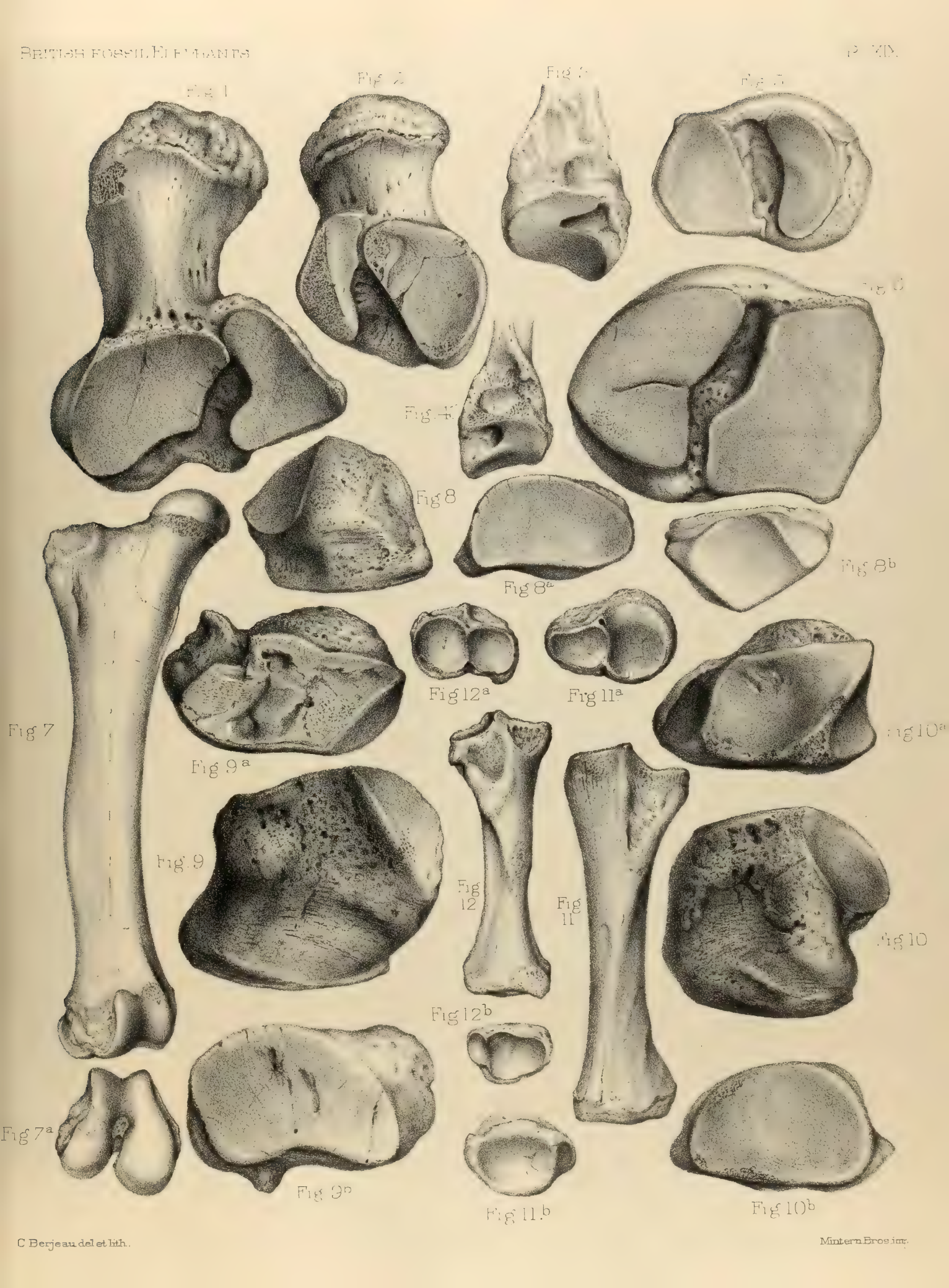
Fig 1
Fig 2
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Fig 7a
Fig 8
Fig 8a
Fig 8b
Fig 9
Fig 9a
Fig 9b
Fig 10
Fig 10a
Fig 10b
Fig 11
Fig 11a
Fig 11b
Fig 12
Fig 12a
Fig 12b

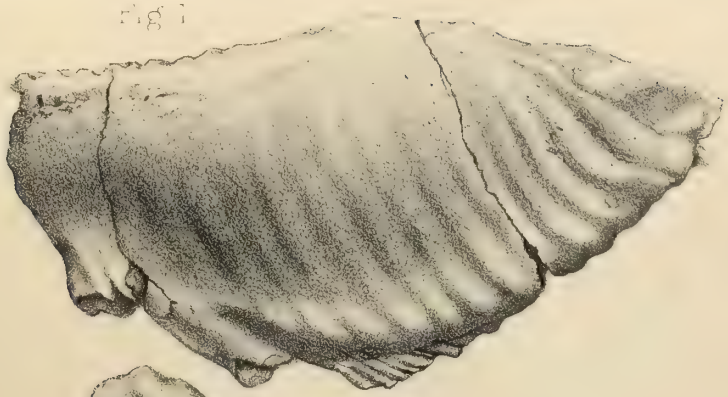
PLATE XX.

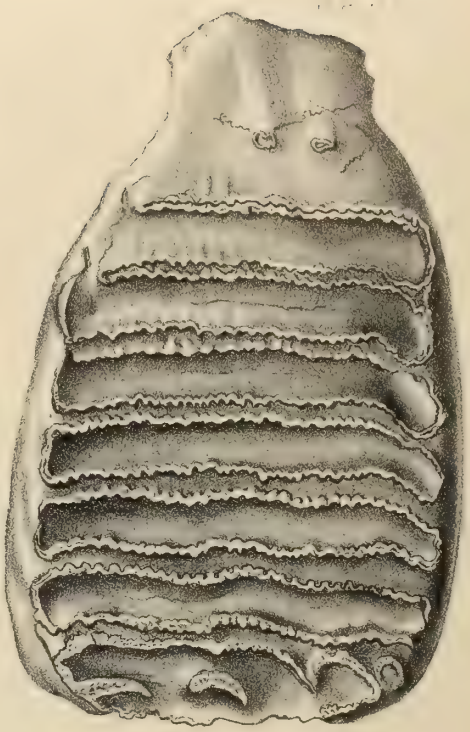
Fig. 1. Profile view of a right lower last true molar of the broad-crowned variety of *E. antiquus*, in the possession of J. J. Colman, Esq., M.P., from the Forest Bed at Corton, Suffolk. (Much reduced.)

Fig. 1 *a*. Crown view of fig. 1. ($\frac{1}{4}$ natural size.)

Fig. 2. Crown view of a right upper last true molar of the broad-crowned variety of *E. antiquus* from the same locality. ($\frac{1}{4}$ natural size.)

Fig. 3. Fragment of a crown of a true molar of *E. primigenius* (*?*), in the possession of A. Savin, Esq., from the Forest Bed, Overstrand, near Cromer, Norfolk. (Natural size.)





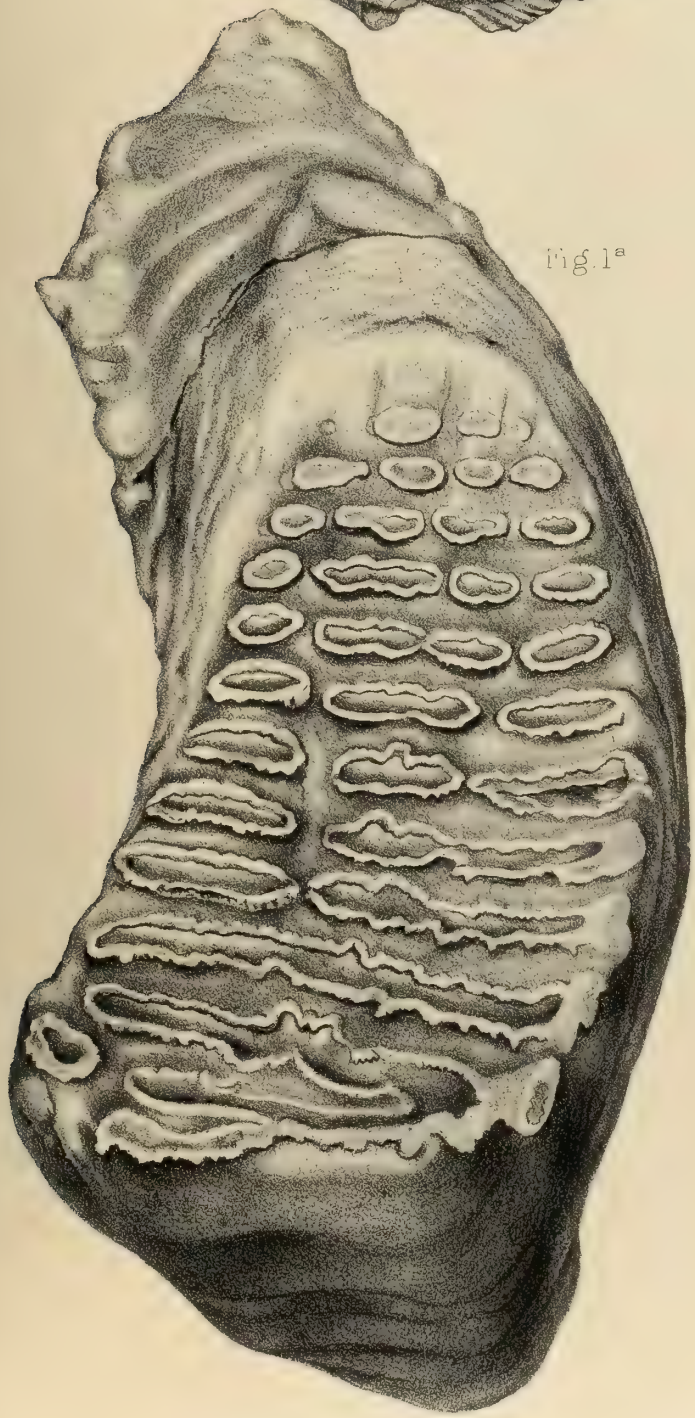


Fig. 1

Fig. 1a

Fig. 2

PLATE XXI.

Figs. 1 and 1 *a*. Crown and profile views of a left upper first true molar of *E. primigenius*, in the possession of Mr. A. Savin, from the Forest Bed, Overstrand, near Cromer. (Fig. 1 natural size, fig. 1 *a* $\frac{3}{4}$ natural size.)

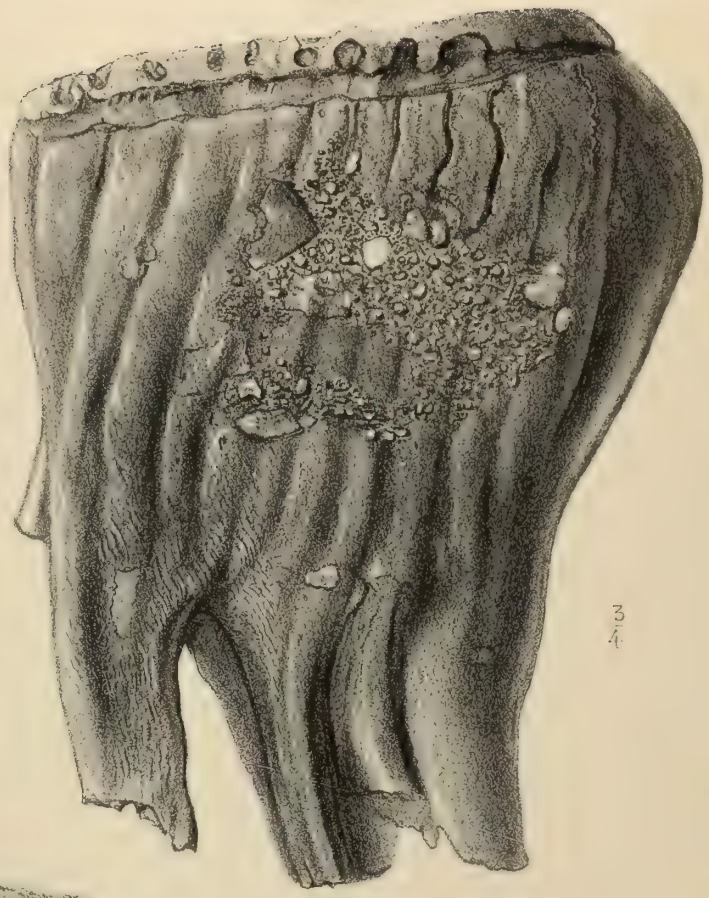
Figs. 2, 2 *a*, and 2 *b*. External, superior, and inferior aspects of a left internal cuneiforme of *E. meridionalis*, No. 188, of the Gunn Collection, from the Norfolk coast. (About natural size.)

Fig. 3. Scaphoidal and metacarpal articular surfaces of No. 23,119, British Museum, a left trapezoid of *E. primigenius*, from Maidstone, Kent. ($\frac{1}{2}$ natural size.)

Fig. 4. Scaphoidal and metacarpal articular surfaces of No. 36,609, British Museum, a left trapezoid of *E. antiquus*, from Grays, Essex. ($\frac{1}{2}$ natural size.)

Fig 1

Fig 1a



3/4

Fig 2

Fig 3

1/2

Fig 4

1/2

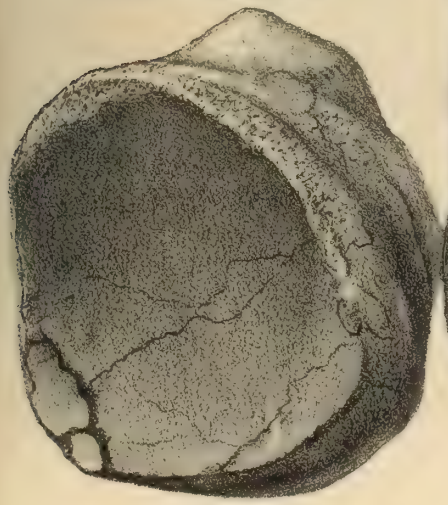


Fig 2a

Fig 2b

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PLATE XXII.

Fig. 1. Crown view of a left upper first true molar of *E. meridionalis*, in the possession of R. Fitch, Esq., of Norwich, from the Forest Bed, Cromer, Norfolk. (Natural size.)

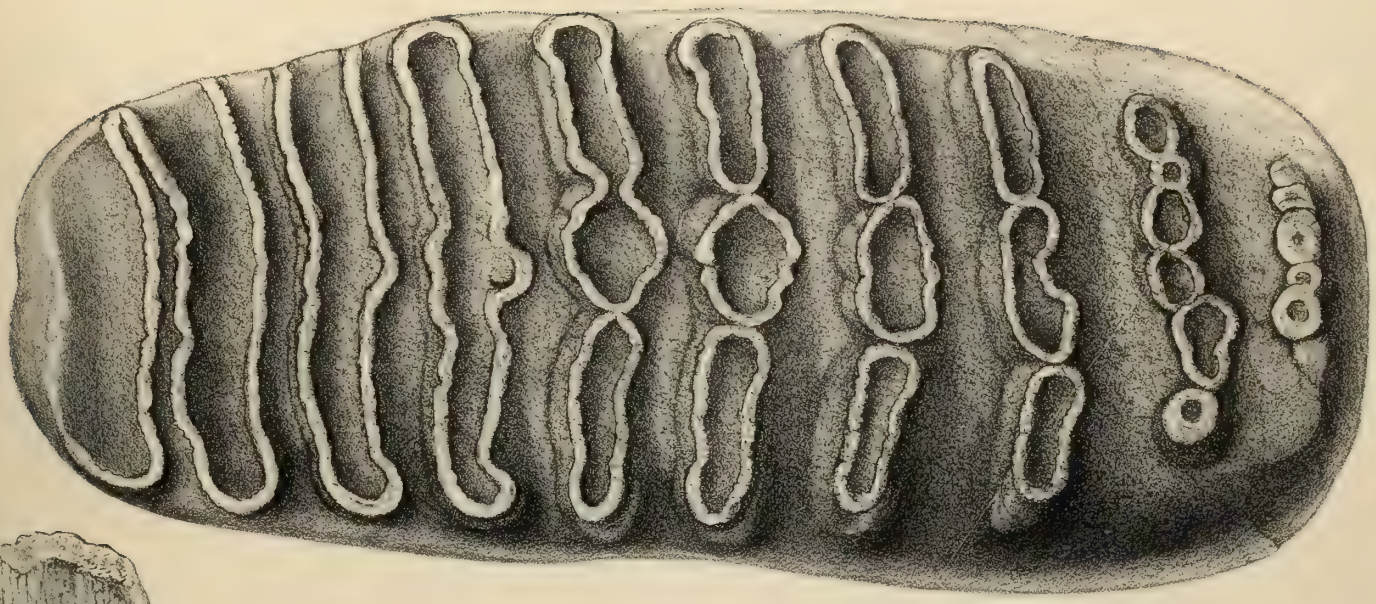
Fig. 2. Portion of the right ramus of a mandible of *E. meridionalis*, containing the two last true molars, No. 215, Gunn Collection, Norwich Museum, from near Mundesley, Norfolk coast. ($\frac{1}{7}$ natural size.)

Figs. 3 and 3 *a*. Fragment of a right ramus of a mandible, with crown view of the penultimate milk molar of *E. meridionalis*, No. 214, Gunn Collection, Norwich Museum, from the Forest Bed, Norfolk coast. (Fig. 3 $\frac{1}{2}$ natural size, fig. 3 *a* natural size.)

Fig. 4. Glenoid cavity of a scapula of *E. primigenius*, Gunn Collection, Norwich Museum, from the Norwich Coast. (Much reduced.)

Fig. 5. Inferior aspect of a femur of *E. antiquus* (*?*), No. 236, Gunn Collection, Norwich Museum, from the Forest Bed, Bacton, Norfolk. (Much reduced.)

Fig. 6. Inferior aspect of a femur of *E. primigenius*, No. 271, Gunn Collection, Norwich Museum, from the Norfolk coast. (Much reduced.)



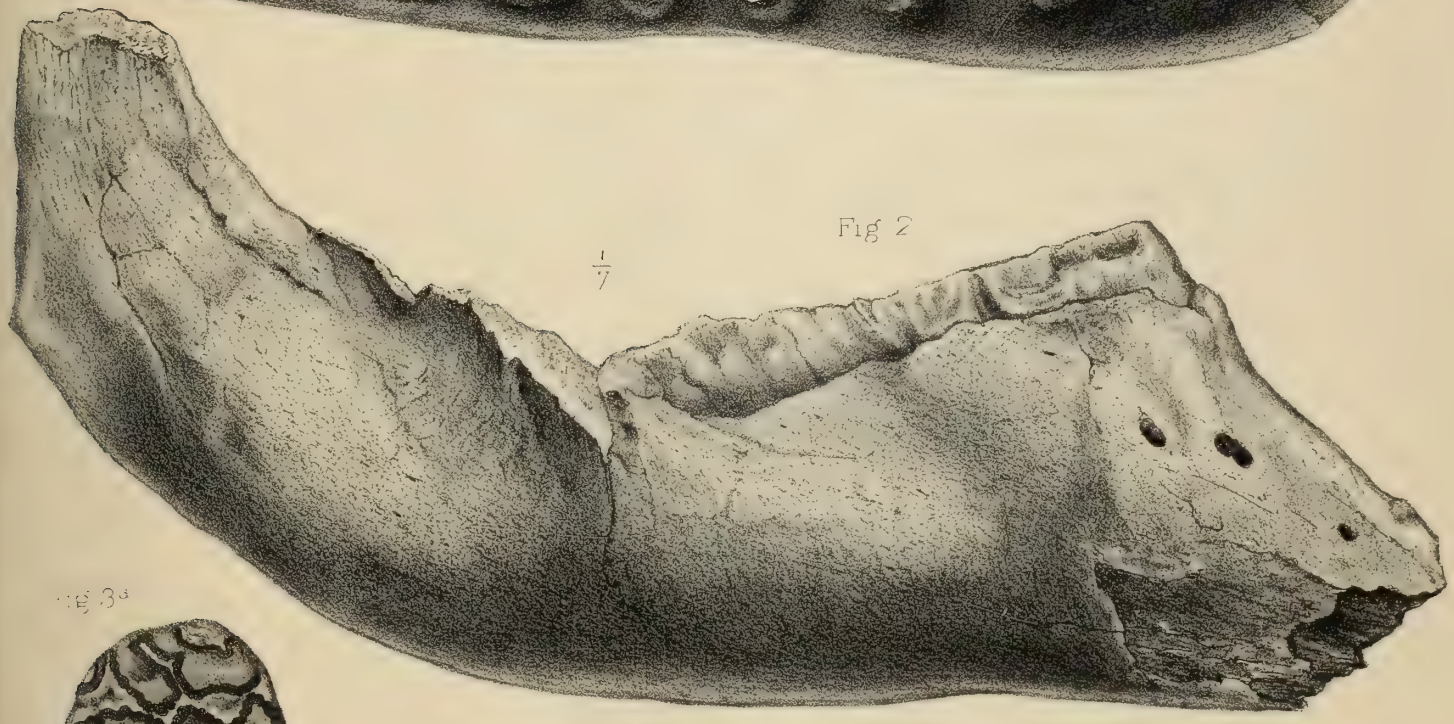


Fig 2

$\frac{1}{7}$

Fig 3a

Fig 5

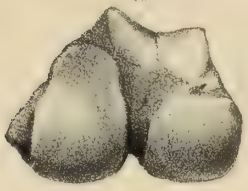


Fig 4

Fig 6

$\frac{1}{2}$

Fig 3

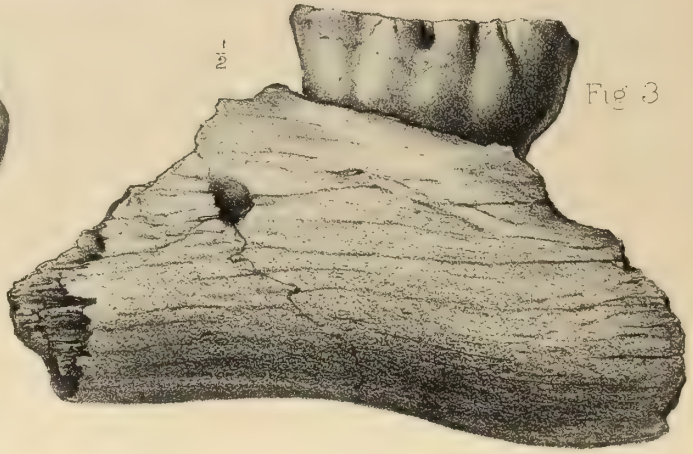


PLATE XXIII.

Figs. 1 and 1 *a*. Crown and profile views of a left lower second true molar of *E. meridionalis*, No. 33,343, British Museum, from the Norfolk coast. (Natural size.)

Fig 1a

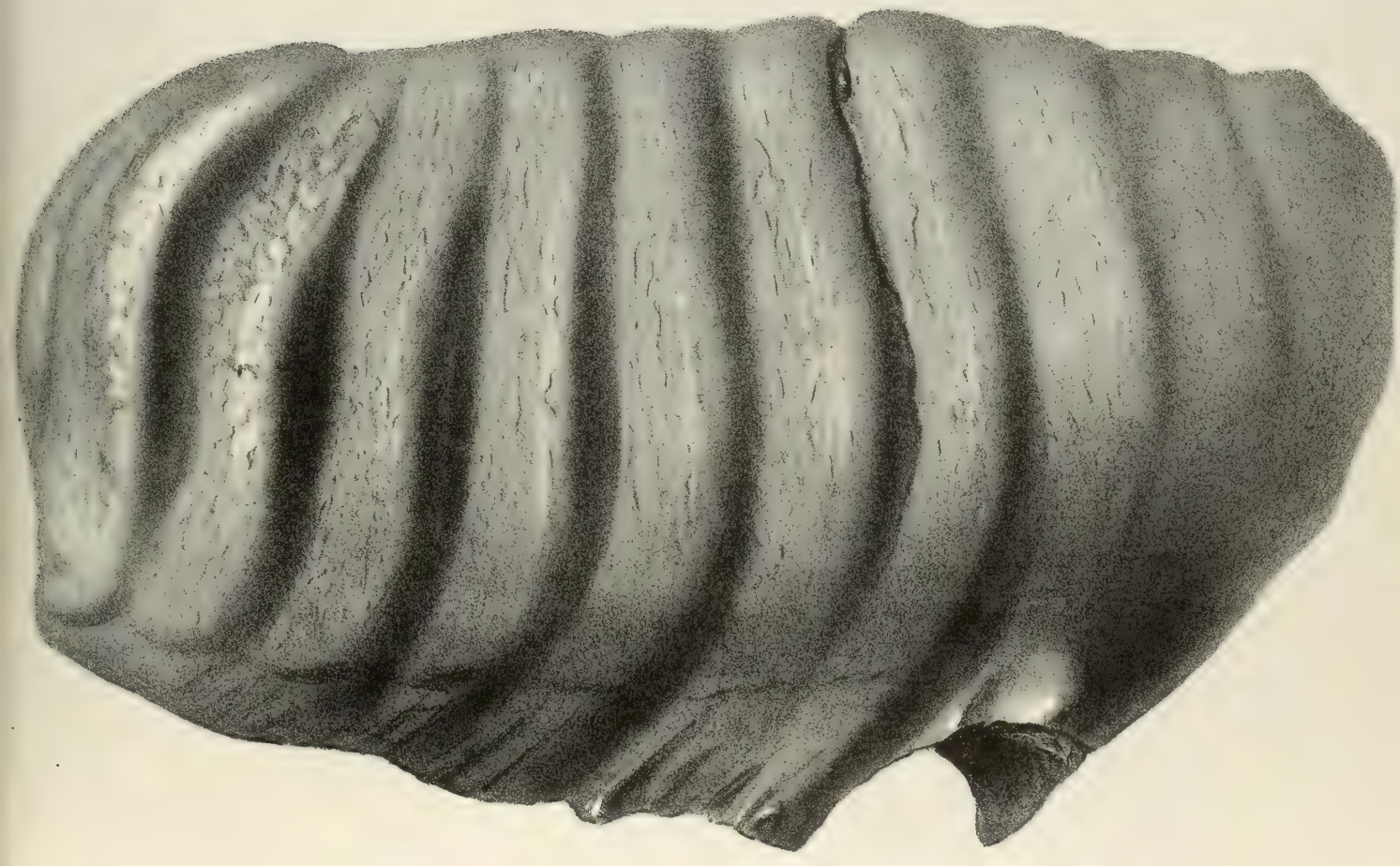
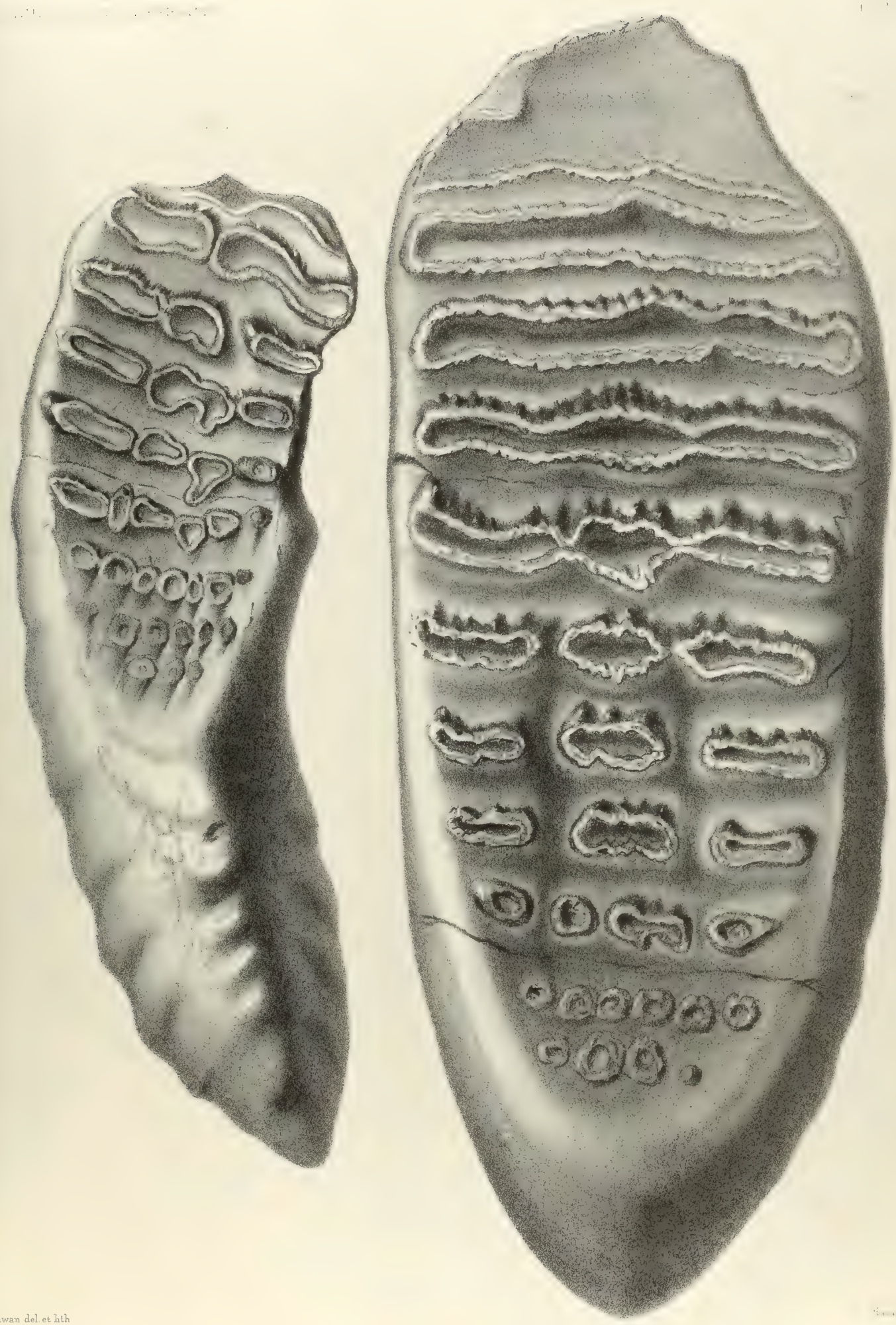


PLATE XXIV.

Fig. 1. A right lower last true molar of *E. meridionalis*, No. 33,354, British Museum, from Happisborough, Norfolk coast. (Considerably reduced.)

Fig. 2. A left upper last true molar of *E. meridionalis*, No. 33,334, British Museum, from the Norfolk coast. (Somewhat reduced.)



A. Gawan del. et lith

PLATE XXV.

Figs. 1, 1 *a*, and 1 *b*. Upper, profile and front views of a mandible of *E. meridionalis*, in the Woodwardian Museum, Cambridge University, from the Forest Bed, Cromer. (Much reduced.)

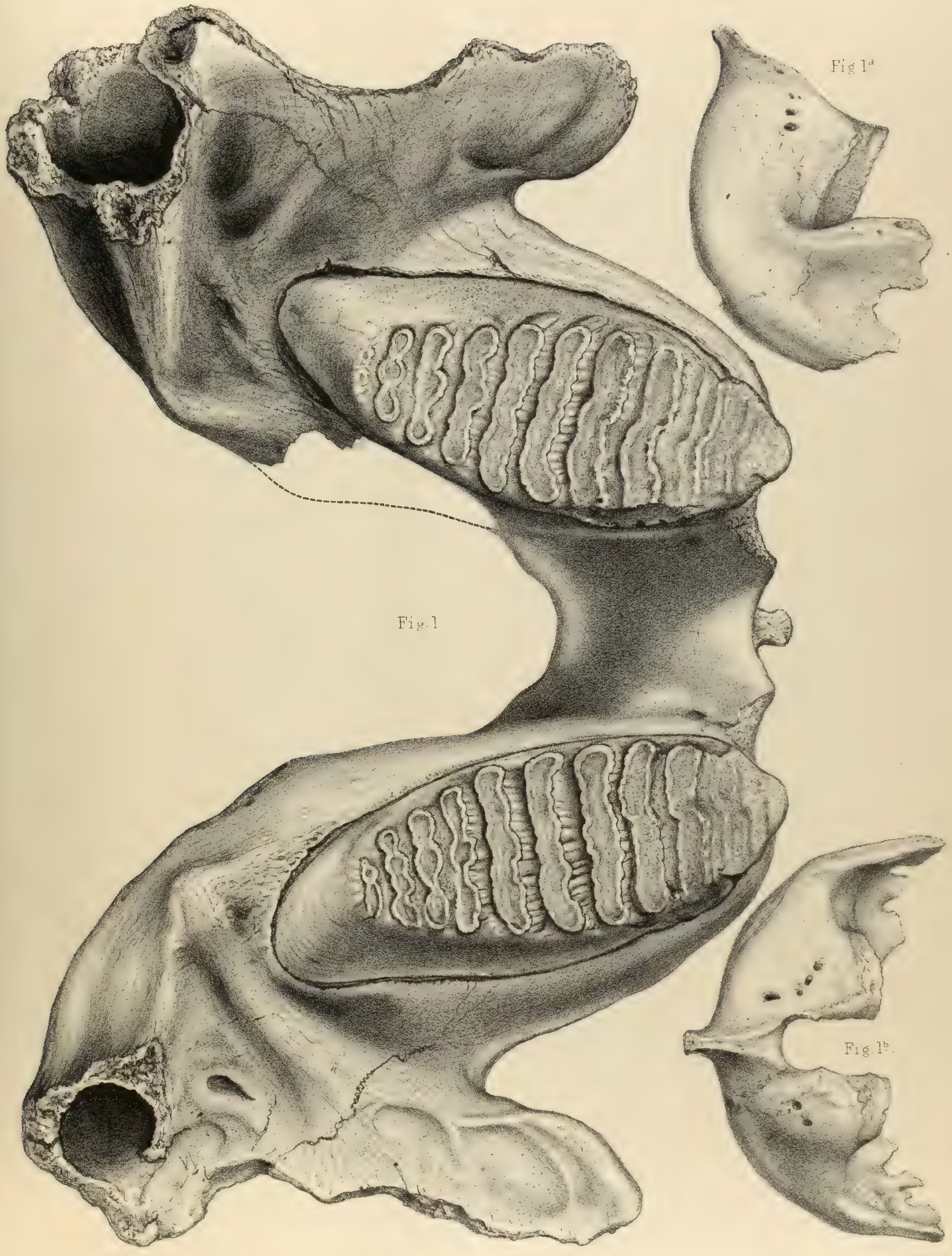


Fig. 1.

Fig. 1a.

Fig. 1b.

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PLATE XXVI.

Fig. 1. Crown view of an abnormal second true molar of *E. primigenius*, from the Norfolk coast. (Natural size.)

Fig. 2. Fragment of the crown of a true molar of *E. antiquus* (*?*), in the Leeds Philosophical Museum, from the Red Crag, Trimley, Suffolk. (Natural size.)

Figs. 3, 3 *a*, and 3 *b*. Anterior, profile, and inferior views of a left femur of *E. meridionalis*, in the possession of J. Backhouse, Esq., West Bank, York, from Overstrand, Norfolk coast. (about $\frac{1}{8}$ natural size.)

Fig. 4. Vertical section of two plates of a true molar of *E. antiquus* (*?*), in the Leeds Philosophical Museum, from the Red Crag, Trimley, Suffolk. (Natural size.)

Fig 1

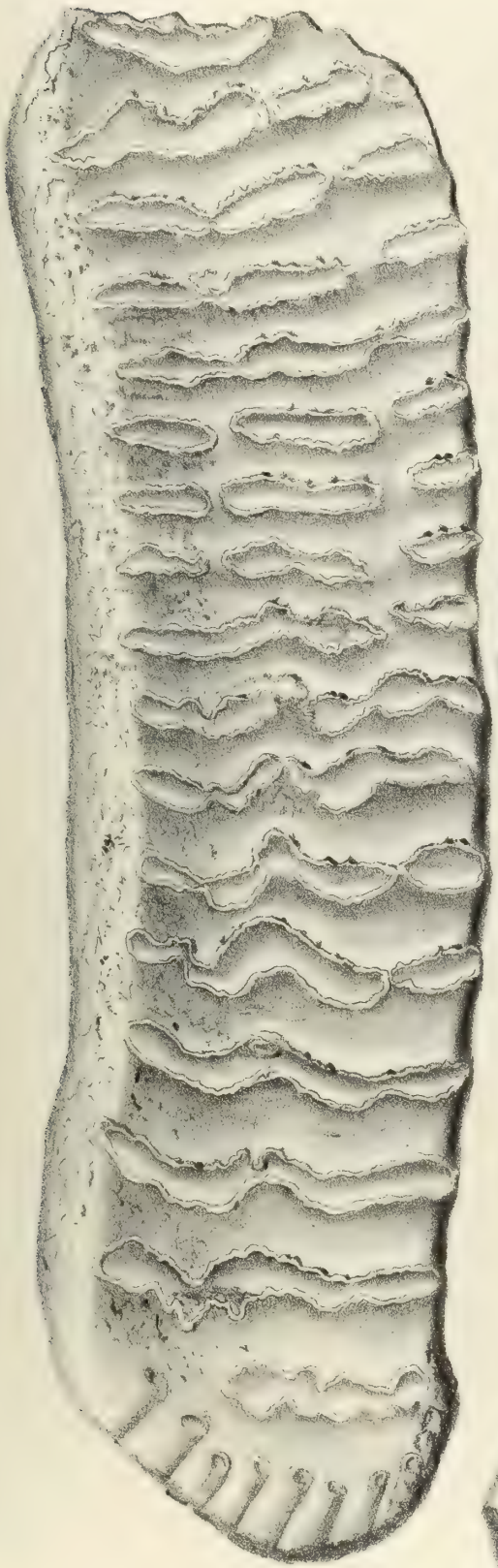

Fig 3ᵇ

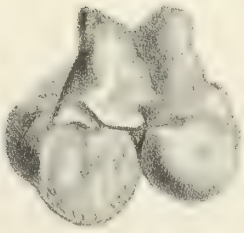

Fig 2

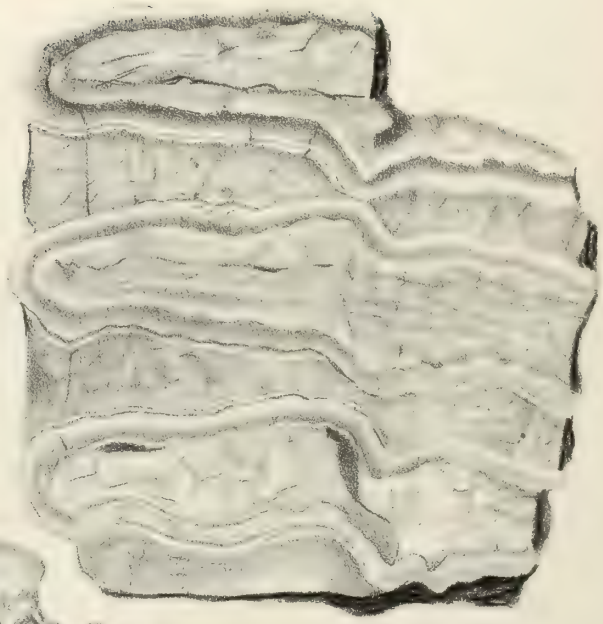

Fig.3

Fig 3ᵃ

rig 4

PLATE XXVII.

Map of the distribution of Elephas antiquus and Elephas meridionalis in England and Wales.

The marks ⊟ and ◇ refer solely to *Elephas antiquus;* no traces of *E. meridionalis* having hitherto been discovered on dry land. In both cases the finds have been most plentiful when either land or trawling operations have been extensively prosecuted.

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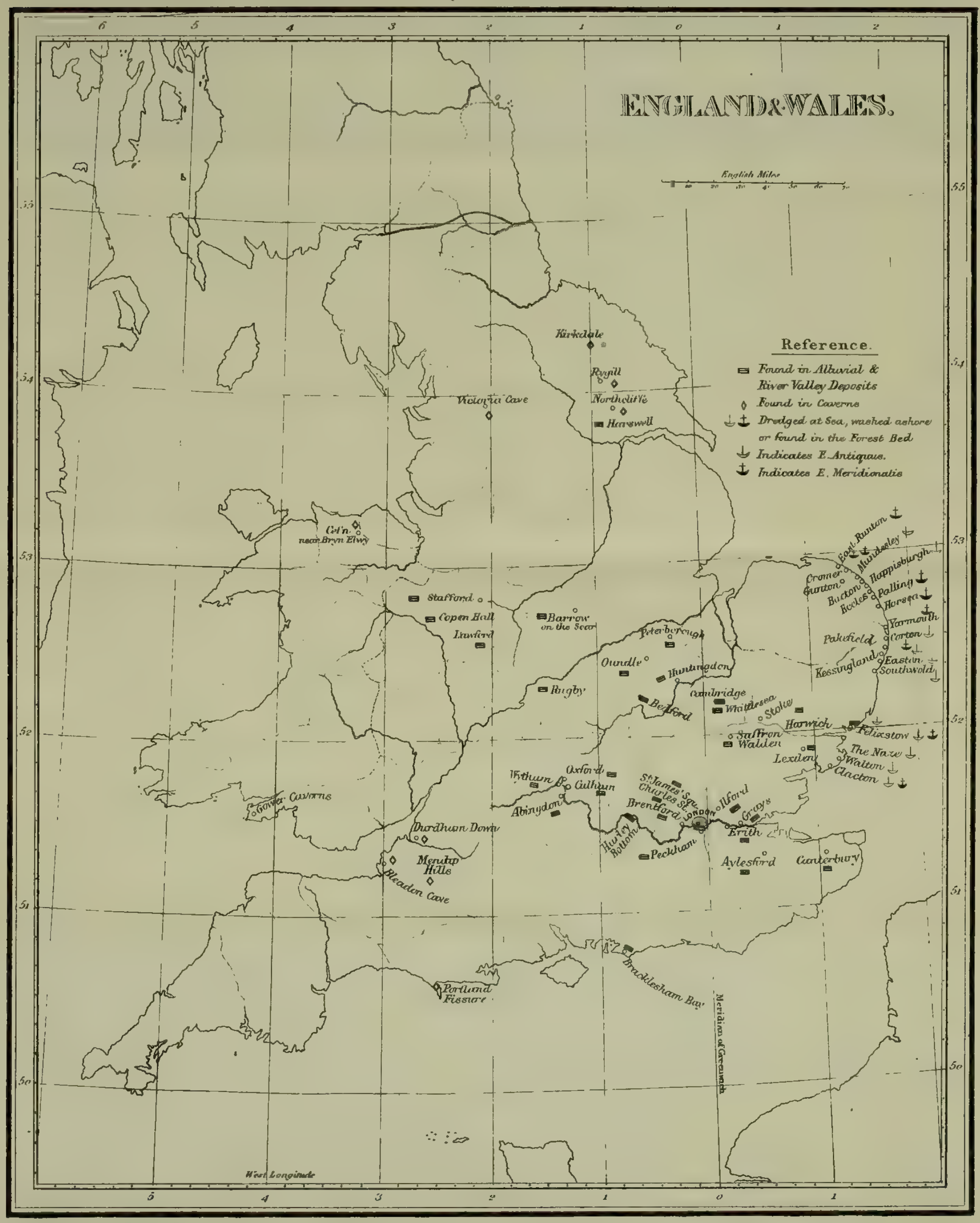

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PLATE XXVIII.

Map of the distribution of Elephas primigenius in England, Wales, Scotland and Ireland.

The most abundant discoveries of *Elephas primigenius* will be seen to prevail in districts where the surface deposits have been most disturbed, to wit, the Valley of the Thames and the chief railway routes. The same is applicable to the dredgings and trawlings along the East coast.

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